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ASTRONOMY AND MODERN NOVELISTS.

By PHILIP H. LING, M.Sc.

H. G. Wells.

In a previous paper * I have discussed the astronomical ideas which underlie some of the stories of Jules Verne. I now propose to do the same with regard to the novels of Mr. H. G. Wells.

Mr. Wells' scientific stories differ from those of M. Verne in several respects. To begin with, they are the work of a man with a thorough scientific training; and then they have frequently some definite object besides that of telling a good story. Mr. Wells is deeply interested in social questions, and, even when as apparently far from Earth as in the discussion of the polity of his imaginary Selenites, criticism of existing terrestrial conditions is never very far out of sight.

The student of astronomy will probably find most to interest him in "The First Men in the Moon" (1901). Here (as in Jules Verne's "De la Terre à la Lune") we are faced with the problem of interplanetary travel. Verne's solution, as I have tried to show, is simple and interesting. Mr. Wells' suggestion, though apparently farther from possibility, is astonishingly ingenious. He imagines the existence of a substance which is absolutely opaque to gravitational lines of force. Given this substance ("Cavorite"), all the properties deduced by Mr. Wells follow quite logically and convincingly. His two heroes journey in a sphere with adjustable blinds, upon which "Cavorite" is painted, and, by raising and lowering these blinds, they are able to move in any desired direction. The sphere leaves the Earth of itself, since its presence (with blinds down) renders all the air above it weightless, and the pressure of the surrounding atmosphere sucks it violently upwards.

The question of the existence of a substance partially or entirely opaque to gravitation is one of great interest. Attempts have actually been made to discover such a substance. Messrs. Austin and Thwing † carried out an experiment to find out whether there existed any difference of gravitational permeability in certain substances. The result was a negative one, but, of course, this does not affect the possibility of special chemical substances with some similar property. It is quite clear that "Cavorite" could not exist in the free state on the surface of the Earth, since an explosion would occur directly it was formed. Mr. Wells arranges that it shall only appear in the last stage of an experiment, in which the heated substances concerned are allowed to cool to 60° F. It is just conceivable that the substance might occur under these conditions; but it would be too elusive to handle, and probably it would not be possible to demonstrate the property in question, or, indeed, to know much more of it than that it was highly explosive. Mr.

* "Knowledge," Volume XXXVII, page 121 (April, 1914).

† *Phys. Rev.*, 1897. See Poynting and Thomson, *Properties of Matter*, 4th edit. (1907), pages 46-8.

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Wells, of course, does not give any idea of the constitution, except that helium and a complicated alloy were involved.

The same volume contains much further matter of interest from our present point of view. The evaporation of the lunar atmosphere at sunrise is very effectively and, as far as can be judged, accurately described, under the assumption that an atmosphere exists. The strange inhabitants of the Moon are the subject of a very ingenious flight of the imagination. Another point raised, though only casually, is the question of the density of the Moon, which, as found by dividing the mass by the volume, is 3·44. The mean density of the Earth is 5·5. How is this to be reconciled with the current idea that the Moon once formed part of the Earth? Sir G. H. Darwin's work on tidal friction has shown how strong is the evidence in favour of such an origin. The disparity is explained by Mr. Wells on the assumption that the Moon is porous, like a sponge; indeed, it must be so if the materials of which it is composed are not different from those found on the Earth—at least in their proportions. He goes on to say that the sponginess is partly natural and partly artificial, the Selenites having piled up some of the ejected matter on the surface, where it forms what terrestrial observers call "the craters." As a result, the water and much of the atmosphere will sink downward through the pores. The artificial origin is a piece of romance not to be taken too seriously; but I hardly see how sponginess of the lunar substance is to be avoided as an explanation of the facts. If this theory is correct, the Moon was porous when it left the Earth, and its porousness may reasonably be attributed to gases escaping from matter in a plastic condition.

In an earlier volume, "The War of the Worlds" (1898), Mr. Wells describes an invasion of England by the inhabitants of Mars. A number of projectiles are fired from the planet, and on their arrival the strangers manage to create a reign of terror by means of their terrible scientific methods of warfare; they are quite different in structure, both from human beings and from Mr. Wells' Selenites. I do not propose, however, to discuss in this place so extensive a question as the habitability of Mars.

"In the Days of the Comet" (1906) describes the collision of the Earth with a comet: this floods our world with a mysterious green gas, which clears the brains of men to such an extent that foolish and stupid practices (such as war) are immediately stopped by general consent. This green gas, with somewhat different properties, appears also in "The War of the Worlds."

There still remain to be mentioned Mr. Wells' short stories, the best of which were collected in 1911, and published in the volume entitled "The Country of the Blind." Of these several, including "The Star" and "The Crystal Egg" (both reprinted from "Tales of Space and Time"), are of some astronomical interest.

From some points of view, "The Star" may be regarded as one of the very finest pieces of scientific writing which Mr. Wells has given us. It describes—as a historian might describe—how a dark star in space collides with the planet Neptune; and, reduced to incandescence by the impact, the two fall headlong towards the Sun; and, being deviated by the attraction of Jupiter, narrowly miss striking the Earth. It is a remarkable story, the only point which seems a little doubtful being whether, if the attraction of Jupiter produced so large an effect, the star itself would not miss the Sun, so as finally to form a double star.

The interest of this story is much increased by the striking resemblance in language with that used by Professor Lowell in his book, "The Evolution of Worlds," published in 1909, ten years after "Tales of Space and Time." Professor Lowell sees the end of the solar system in an impact with some external dark sun, very much as Mr. Wells describes. There are differences of detail; for instance, Professor Lowell's star does not collide with any planet, because he supposes its initial velocity to be nothing; and since the Sun's path is considerably inclined to the ecliptic the star's path will be nearly in the same line. The destruction in Mr. Wells' story is also by no means so complete as Professor Lowell foretells.

"The Crystal Egg" is a very curious tale of a piece of crystal which appears to be telepathically *en rapport* with a similar piece on Mars, so that it may be possible, for certain individuals, on looking into the "egg," to see something happening on the other planet. "Under the Knife," another short story, is also of some astronomical interest.

From what has been said above, it will be seen that we owe to Mr. Wells several highly interesting ideas. During the last few years he has concerned himself largely with the novel, and with studies of the future of the human race. With the exception of the suggestions about induced radio-activity in "The World Set Free," we have had from his pen little relating to pure science. We may be permitted to regret that he has not found time to give us another astronomical novel.

Note.—Since the above was written I have read a paper on "The Terrestrial Distribution of Radium," by Mr. Arthur Holmes, in *Science Progress* (July, 1914), which throws some light on the question of the Moon's structure. According to the latest theories, the Earth contains two or more distinct zones of different composition, the outer one having density 3·4, *i.e.*, that attributed to the Moon. It would therefore appear that the Moon is not necessarily of a spongy form, provided it is completely made up from material such as that found at the surface of the Earth.

SPINNING AND WEAVING IN EARLY TIMES.

By H. R. CARTER.

THE spindle for twisting fibre into thread and the loom for interlacing these threads at right angles into cloth are prehistoric tools, and older than the history of mankind. In the remains of the lake dwellings of Neolithic man have been found pieces of thread spindles, and spinning wheels, proving the spinning of fibres, and weavers' weights and remnants of cloth, some of them twilled, proving the existence and skill of the weaver.

The primitive spinning and weaving implements still used by the natives of India and China are almost identical with those used in the most ancient times, while those abandoned by the Scotch, Irish, and Welsh peasantry within the memory of the present generation are almost as primitive. In the country parts of Japan, too, the spinning wheel is still much used, although rapidly giving place to factory methods.

Very early examples of the spinner's art are extremely rare, owing, of course, to the perishable nature of the fibres used. Most of them are contained in shreds of textile fabrics, such as the linen cloths unwrapped from Egyptian mummies; for the Egyptians of old were expert spinners and weavers, and did a large export trade with Europe and distant parts of Africa and Arabia in textile fabrics, the fine linens of Egypt especially being unrivalled in the ancient world for evenness and fineness of texture. In Exodus we read: "And all the women that were wise-hearted did spin with their hands," an art the Israelites no doubt learnt from their captors.

The Egyptians regarded the spinning of a single thread as so wonderful that they ascribed the invention of the art to the goddess Isis.

In one of the lake dwellings of Switzerland, discovered in the bed of the lake at Robenhausen in 1882, were bundles of raw flax fibre, fine and coarse linen threads, twisted strings of various sizes, and thick ropes as well as netted and knitted fabrics and fragments of cloth, sometimes rudely embellished with needlework. There were also found spindle whorls, fragments of wooden wheels, which probably formed parts of spinning wheels, charred spindles with thread wound upon them, and toothed combs, which were probably used for preparing the raw fibre.

Primitive man discovered that various vegetable and animal fibres, even short ones, could be twisted together and joined up into threads of any required length and thickness. He likewise found out, by experience no doubt, that fine filaments produce the finest and levellest threads, and that some comparatively coarse fibres might be split up by combing, carding, and hackling.

From the evidence at our disposal it would appear that it was during the later Stone age that mankind selected the principal textile fibres and acquired the art of spinning and weaving proper. It is obvious that these efforts of the weaver's craft would be as primitive as man himself. His demands were of the simplest description. He would only need clothing and something for shelter, and for these purposes he would use such fibrous materials as came to his hand easily, such as grasses long enough in their natural condition for interlacing or plaiting; but each step in the progress of man from the state of savagery to civilisation would be marked by a corresponding advance in the manner in which he clothed and sheltered himself, and, as culture dawned, the simple demands of mere necessity would be developed by the need of variety or by the desire for colour and ornament. The use of multicoloured threads provided ornament for the simple structures in use, but the demand for variety would extend far beyond the limits of colour, and different materials were employed, either separately or conjointly, and different schemes of interlacing were evolved.

The Egyptians were probably the first skilled weavers of civilisation, for as early as 1800 B.C. the arts of spinning and weaving were extensively practised. The Bible records that Pharaoh arrayed Joseph in vestures of fine linen (Genesis xli, 42). This occurred in 1716 B.C. It was undoubtedly in Egypt that the Israelites obtained the skill in weaving which enabled them to execute the hangings of the Tabernacle and other artistic textures in 1491 B.C. (Exodus xxxv, 35). Pictures found at Beni Hassan of pre-Thebian origin, 1500 B.C., show flax workers engaged in linen manufacture. Tanaquil, wife of Tarquinius Priscus, in 613 B.C., is said to have been the first to weave a straight tunic on a perpendicular loom. This form of tunic was worn for many centuries under the white toga by the younger Roman citizens.

Cotton spinning and weaving are known to have existed in India for upwards of three thousand years. Herodotus mentions the cotton drawers worn by the Indian contingent of Xerxes' army. The same writer also mentions hemp, saying that Thracians made garments of hemp which closely resembled linen.

Pliny, in his great work, *Historia Naturalis*, published in the year A.D. 77, gives interesting notes on flax and hemp cultivation and manufacture.

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In his account of flax, he gives the reason why flax is not a favourite crop with farmers. "It has the property," he says, "of scorching the ground where it is grown, and of deteriorating the quality of the very soil itself."

Egyptian weavers were men, for Herodotus assures us that the women of Egypt were employed abroad in trade and business, but the men were left at home to spin and weave.

In the Chronicles, the writer, speaking of the families of the house of them that wrought fine linen, bears out the idea that the trades of spinning and weaving were carried out by a particular tribe or family.

Syria was early noted for its cloths. As to the celebrated Syrian purple, it is estimated that it cost £32 to colour one pound of wool.

Felt was probably manufactured before yarn was woven into cloth, the method of producing it being accidentally discovered. Felt manufacturers take St. Clement for their patron saint, because, they say, the saint, before starting on a long pilgrimage, put soft wool inside his shoes, and found at the end of his journey that the layer of soft fibres had been converted into cloth by the action of his feet. Be this legend true or not, felt cloth was manufactured at a very early date, such cloth being sometimes of such a texture as to form a protection against the bows and arrows of that day.

The Israelites were forbidden to wear a garment made of a mixture of flax and wool. It is said that this was to prevent idolatry, as heathen priests wore such mixed garments in the hope of a lucky conjunction of the planets bringing down a blessing upon their sheep and flax. Furthermore, no man could enter the temple with garments having any wool fibre about them, and no man could expect a resurrection from the dead whose body had been buried in woollen clothes.

In olden times, as in some countries and places to-day, women took a pride in boasting that their husbands and children were solely clothed by the labour of their hands.

A passage from the Proverbs gives the character and occupation of an industrious housewife among the Hebrews: "She seeketh wool and flax, and worketh willingly with her hands. She layeth her hands to the spindle, and her hands hold the distaff. All her household are clothed with scarlet. She maketh herself a covering of tapestry, her clothing is of silk and purple. She maketh fine linen and selleth it."

The art of spinning was also once popular in the homes of the great. Homer represents some of the most distinguished maidens as so employed. Penelope plied the spindle and loom, and tasked her maidens. The fairy tale of King Crotchet's wife may also still be fresh in the memory of some. All these legends go to prove, then, that—

> "To spin with art in ancient times was seen,
> Thought not beneath the noble dame or queen;
> From that employ our maidens took their name
> Of spinsters, which the moderns never claim."

Our maidens are still "spinsters." In heraldry and genealogy one talks of the "distaff" side of a family, the female side, the side which spun the thread from which the cloth was woven in which the "spear" side went forth to fight; and, although the distaff and the spinning wheel no longer find an active place in any ladies' boudoir, we still depend upon the distaff side for much of the clothes we wear.

The spindle for twisting fibre into thread is, as we have said, a prehistoric tool. Figure 19 shows several examples. It is essentially a short stick with a weight or whorl at one end and a hook or notch at the other, the thread, when spun, being wound between these two. As seen in Figure 20, the primitive spinner carried a bundle of fibre to be spun upon the end of a stick, "rock," or distaff, carried under the left arm. She first drew out a few fibres, and, twisting them in her fingers, attached them to the hooked end of the spindle, which she then rotated with one hand, while she continued to draw out fibres with the other. When a convenient length was spun it was wound upon the spindle, and a fresh length commenced. Homer, describing Ulysses following Ajax, employs the following figure:—

> "As when some dapper, geraled wife
> Near the bosom holdeth
> The spindle, whence she draweth out
> The rove beyond the sliver,
> So near Ulysses kept and trod
> The very prints of Ajax."

One great advantage this primitive spindle had over modern machines was that it could be carried about by the spinner without her having to discontinue the work. An ancient story by Herodotus illustrates this point. King Darius chanced to see a Phoenician woman, who was carrying a pitcher on her head, leading a horse and spinning, all at the same time. He sent spies after her, and they reported that she filled the pitcher, watered the horse, and returned, continuing all the time to spin with her spindle. Darius asked if all the women of Phoenicia were so industrious, and, being told that they were, ordered that all the Phoenicians —men, women, and children—should be removed from their own country into Persia.

Whether this reward of merit was appreciated by the Phoenicians or not, Herodotus does not say.

The spinning wheel, progressive types of which are shown in figures 21, 22, and 23, and which is not unknown, no doubt, to some of our readers, was the next development in spinning machinery, and is still in use in China, Japan, and various Eastern countries, as well as in remote parts of Ireland, Scotland, and Wales, where home industries still linger.

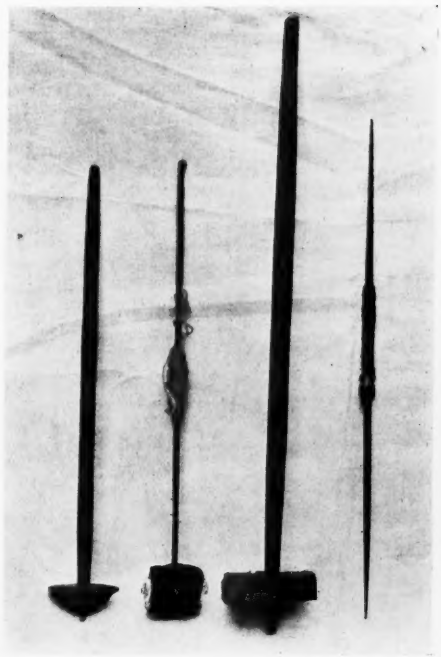

FIGURE 19. Early Spindles. From the Horner Collection, Public Museum, Belfast.

FIGURE 20. A girl spinning by hand.

FIGURE 21. Indian Spinning Wheel. From the Horner Collection, Public Museum, Belfast.

FIGURE 22.

Spinning Wheel. From the Horner Collection, Public Museum, Belfast.

FIGURE 23.

Spinning Wheel. From the Horner Collection, Public Museum, Belfast.

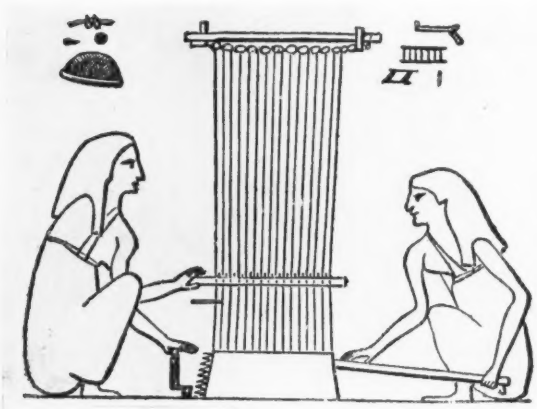

FIGURE 24.

An Egyptian Loom as represented on a tomb.

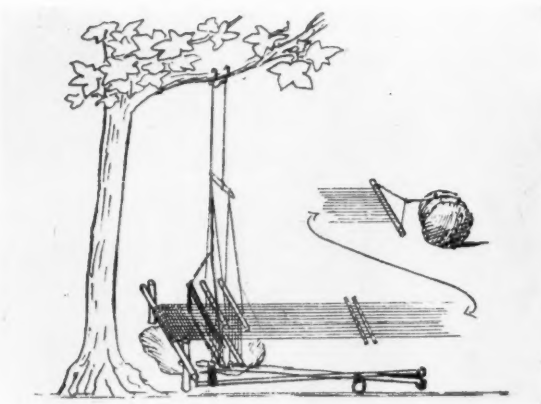

FIGURE 25.

Indian Hand Loom.

In its most perfect form it is an ingenious arrangement, by means of which the two operations of twisting the thread and winding it up are done simultaneously.

We have mentioned that Penelope and her maidens plied the loom. A Greek vase-painting, dated about 500 B.C., shows us that this loom was arranged in a similar way to those in which Oriental carpets are woven by hand to-day, *i.e.*, the warp threads hang vertically downwards, and the woven cloth is wound upon a roller above, the fabric and pattern being produced by interlacing the weft threads in various ways and order. On a small vase in the British Museum there is a sketch of a lady weaving on a small frame supported on her lap.

The character of still earlier looms, and the process of weaving, can only be inferred from incidental notices. The Bible does not notice the loom itself, but speaks of the beam to which the warp was attached; for example (1 Samuel XVII, 7), 1063 B.C.: "And the staff of his spear was like a weaver's beam"; also of the pin to which the cloth was fixed, and on which it was rolled. For instance (Judges XVI, 14), where Delilah fastened Samson with the pin: "And he awaked out of his sleep, and went away with the pin of the beam, and with the web."

We also have notice of the shuttle, which is described by a term significant of the act of weaving (Job VII, 6), 1520 B.C.: "My days are swifter than the weaver's shuttle."

The "thrum" or threads which attached the web to the beam are taken notice of in Isaiah XXXVIII, 12): "I have cut off like a weaver my life; he will cut me off" from the thrum (see marginal reading).

Ovid writes:—

"The web enwraps the beam, the reed divides,
While through the wid'ning space the shuttle glides,
Which their swift hands receive, then, poised with lead,
The swinging weight strikes close the inserted thread.
Each girds her flowing garments round her waist,
And plies her feet and arms with dexterous haste."

The Egyptian loom, as seen in Figure 24, was usually upright, and the weaver stood at his work, the cloth being fixed sometimes at the top and sometimes at the bottom of the loom. Pictures of primitive looms in many cases exhibit no feasible shedding apparatus, while the implements found to be used for carrying the weft lead us to believe that the operation of weaving in those days partook largely of the nature of darning. Probably the oldest representations of looms existent are those to be found on ancient Egyptian tombs. Several of these have been found at Thebes, on tombs fixed by the best authorities as belonging to the period about 3000 B.C. Figure 24 is a reproduction of a drawing of one of those looms. It is probable that the Egyptian form of loom was carried first to Greece, and thence to Italy, without suffering much change in its migration.

Montfaucon, a French monk, writing in the early part of the eighteenth century, refers to a work, believed to be of the fourth century, in which a Grecian loom is shown, which differs very little from the Egyptian one here shown.

The process of inserting the rod carrying the weft alternately over and under the warp, as a woman does her needle in darning, is obviously a tedious one, and would decidedly limit production. The necessity, therefore, for some means of separating the warp would soon assert itself.

The most ancient type of heddles, or camb, known, is also traced to Egypt, and consisted of a rod over which a number of simple loops of twine were passed through which the warp threads were drawn. For plain cloth two of these would be required to act upon alternate threads. Figure 25, which is, however, from an Indian source, shows this. There is no reed—just two heddle shafts which are actuated by hand. The weft is brushed into the fell of the cloth, and then beaten up by a stick.

In the Egyptian form of loom, the weft seems to have been drawn through the shed by a hook fixed on the end of a rod. It would then develop into passing the stick, with the weft wound upon it, through the shed, and from this would develop a piece of wood, or shuttle, specially shaped for the purpose of conveying the weft through the shed, and into which fresh supplies could readily be passed. When heddles for shed-forming were invented, this piece of wood became quite short and pointed, and was thrown by one hand from one side of the loom, and caught by the other hand at the other side when the web was a narrow one. Upon broad looms two weavers had to be employed, one at each side, to throw the shuttle in turn to each other. The task of the weaver of that day is thus described by Dyer in verse:—

"He chooses some companion to his toil,
From side to side with amicable aim,
Each to the other darts the nimble bolt,
While friendly converse, prompted by the work,
Kindles improvement in the opening mind."

Thus, in the course of centuries, the ancient hand-loom was gradually improved. Probably the first step was the winding of the warp upon a roller, and the finished cloth upon another.

Next heddles were invented, and the warp was placed horizontally. Then the reed for pushing up the weft into its place was fixed in a swinging sley, upon which the shuttle slid as it was pushed or thrown across, and through the shed formed by the warp threads and heddle.

The title of our article forbids our following the development of the shuttle and the loom any further, although the history of and the opposition offered to the inventions of Paul Arkwright, Hargreaves, Crompton, Kay, and Cartwright, which resulted in the modern spinning frame and power loom, make interesting reading.

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ON THE CONSTRUCTION OF REGULAR POLYGONS.

By L. SILVER, B.Sc. (Lond.), A.R.C.S.

IN "KNOWLEDGE" for September, 1913, there appeared a paper by Messrs. Redgrove and Coles giving an account of some investigations on the construction of regular polygons. Four methods were described for constructing polygons having any given number of sides and on a given base. The following is an account of a method investigated by the

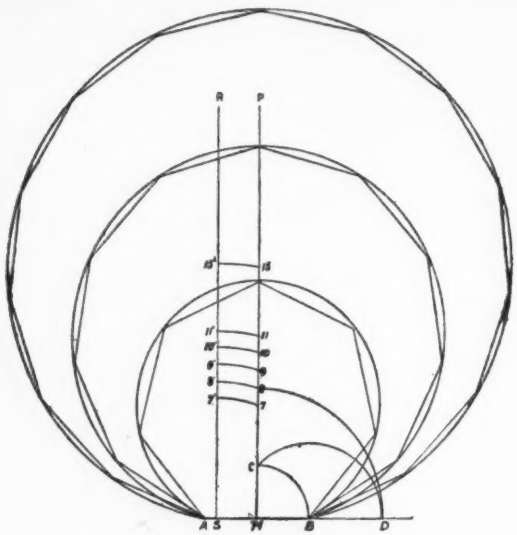

FIGURE 26.

author which is more accurate and more general in application than any of those described in the above-mentioned paper.

Let AB (see Figure 1—) be the base of the required polygon. Bisect AB in M and draw MP perpendicular to AB. With M as centre and MB as radius describe an arc cutting MP at C. With B as centre and BC as radius describe an arc cutting AB produced in D. With M as centre and MD as radius describe an arc cutting MP in the point 8. (The above part of the construction is taken from Messrs. Redgrove and Coles's paper.) Trisect MB and mark the point 9 on 8P, so that $89 = \frac{1}{3}MB$. Divide AM into five equal parts, and mark S so that $MS = \frac{4}{5}AM$. At S draw SR perpendicular to AB. With centre S and radius S8 describe an arc cutting SR at 8′. With centre S and radius S9 describe an arc cutting SR at 9′. Mark points 10′, 11′, and so on, along 9′R so that 9′10′, 10′11′, and so on, are each equal to 8′9′. Similarly mark points 7′, 6′ along 8′S. With centre S and radii S6′, S7′, S10′, S11′, and so on, describe arcs cutting MP in the points 6, 7, 10, 11, and so on, respectively.

Then points 6, 7, 8, 9, 10, and so on, are the centres of the circumscribing circles of polygons on base AB having the number of sides corresponding to the numbers against the points. With these points as centres draw circles passing through A and B. By stepping off the length AB round the circumference the angular points of the polygons are obtained.

Figure 1— shows polygons of 7, 11, and 15 sides respectively.

The formula governing the height, above the base, of the centre of the circle circumscribing a regular polygon is $\frac{h}{a} = \text{cotan } \frac{\pi}{n}$, where h is the length of the perpendicular from the centre on the base, a is the length of half the base, and n is the number of sides of the polygon. If half the base be taken as unit length ($a=1$) then $h = \text{cotan } \frac{\pi}{n}$. (In all that follows half the base is taken as unit length.) The values of h for successive values of n are given in Column 2 of Table 1. Column 3 gives the differences between successive values of h; that is, the distances between the centres of the circumscribing circles of successive polygons on the same base. The table shows that these distances (denoted by d) are not constant, but decrease as the number of sides of the polygon increases. When the number of sides is fairly large d is very nearly constant; and when n becomes very large d approaches a definite limit.

$$\text{For, } d = \text{cotan } \frac{\pi}{n+1} - \text{cotan } \frac{\pi}{n} = \frac{\cos \frac{\pi}{n+1}}{\sin \frac{\pi}{n+1}} - \frac{\cos \frac{\pi}{n}}{\sin \frac{\pi}{n}},$$

When n is indefinitely large $\cos \frac{\pi}{n+1} = \cos \frac{\pi}{n} = 1$,

and $\sin \frac{\pi}{n+1} = \frac{\pi}{n+1}$, and $\sin \frac{\pi}{n} = \frac{\pi}{n}$.

Hence when n is indefinitely large

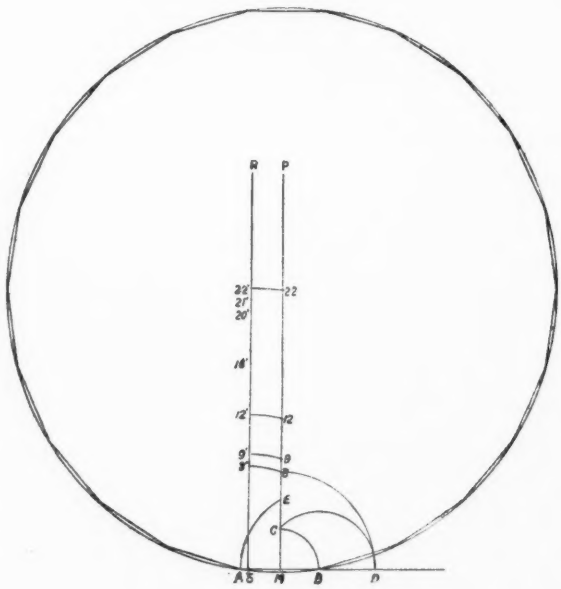

FIGURE 27.

$$d = \frac{1}{\frac{\pi}{n+1}} - \frac{1}{\frac{\pi}{n}} = \frac{n+1}{\pi} - \frac{n}{\pi} = \frac{1}{\pi}.$$

This can also be shown geometrically; for, when n is indefinitely large, the polygon becomes a circle and d becomes the difference between the radii of two circles

whose circumferences differ by two units (*i.e.*, by the length of one side of the polygon).

But the radius of a circle = circumference $\div 2\pi$;

hence limit of $d = \frac{2}{2\pi} = \frac{1}{\pi} = \cdot 3183$.

Columns 4 and 5 of the table give the values of h and d respectively, obtained by using the construction described above. It will be seen that in every case where n is greater than 4 the values obtained by this method are in very close agreement with the correct values given in Columns 2 and 3.

It can be shown that the values of d found by this method also decrease towards the limit $\frac{1}{w}$.

For

$$M8 = MD = MB + BC = 1 + \sqrt{2} = 2{\cdot}4142$$

(= cotan $\frac{w}{8}$; hence 8 is the centre of the circle circumscribing an octagon on AB as base).

true value of h (Column 2) and the value obtained by using the above construction (Column 4). In all cases this error is very minute. In fact, the error is not greater than ·001 for polygons having any number of sides from six to over three hundred.

This means that if the base is 1″ long the error in the position of the centre of the circumscribing circle is not greater (theoretically) than ·0005″. Hence the theoretical error in the length of the circumference is not greater than ·003″.

In practice, then, the method may be regarded as absolutely accurate.

The formula giving the distance h for this method in terms of the number of sides of the polygon is found as follows: Let the centre of the circle circumscribing a polygon of n sides be denoted by N, and let the corresponding point on SR be N′;

TABLE 1.

1	2	3	4	5	6
n = No. of sides.	h = cotan $\frac{\pi}{n}$.	d = difference.	h = $\sqrt{(\cdot 3183n - \cdot 0034)^2 - \cdot 64}$.	d = difference.	*Error* = h(col. 4) − h(col. 2).
3	0·577		0·515		−·062
		·423		·471	
4	1·000		0·986		−·014
		·376		·385	
5	1·376		1·371		−·005
		·356		·360	
6	1·732		1·731		−·001
		·344		·345	
7	2·076		2·076		·000
		·338		·338	
8	2·414		2·414		·000
		·333		·333	
9	2·747		2·747		·000
		·331		·331	
10	3·078		3·078		·000
		·328		·328	
11	3·406		3·406		·000
		·326		·326	
12	3·732		3·732		·000
		·325		·325	
13	4·057		4·057		·000
		·324		·324	
14	4·381		4·381		·000
		·324		·323	
15	4·705		4·704		−·001
		·322		·323	
16	5·027		5·027		·000
		·322		·322	
17	5·349		5·349		·000
		·322		·322	
18	5·671		5·671		·000
		·322		·321	
19	5·993		5·992		−·001
		·321		·321	
20	6·314		6·313		−·001
		—		—	
—	—		—		—
30	9·514		9·513		−·001
		—		—	
—	—		—		—
60	19·081		19·080		−·001
		—		—	
—	—		—		—
100	31·820		31·820		·000
		—		—	

$M9 = M8 + \cdot 3333 = 2{\cdot}7475.$

$S8' = S8 = \sqrt{M8^2 + SM^2} = \sqrt{(2{\cdot}4142)^2 + \cdot 8^2} = 2{\cdot}54330$

$S9' = S9 = \sqrt{M9^2 + SM^2} = \sqrt{(2{\cdot}7475)^2 + \cdot 8^2} = 2{\cdot}86164$

$\therefore\ 8'9' = S9' - S8' = 2{\cdot}86164 - 2{\cdot}54330 = \cdot 31834.$

Hence it is obvious that 89 is greater than 8′9′, and from Figure 1— it can be seen that as n is increased the distance d between successive points on MP becomes more nearly equal to the distance, d', between the corresponding points on SR.

In the limit, when n is indefinitely large, $d = d'$. But $d' = 8'9' = \cdot 3183$. Therefore the limiting value, when n is indefinitely large, of the distance between successive points on MP is ·3183 or $\frac{1}{\pi}$ (approximately). Hence this method gives a series of distances decreasing towards the same limit as that which the true values of d approach.

Column 6 of the table gives the difference between the

Then $h = MN = \sqrt{SN^2 - SM^2} = \sqrt{SN'^2 - SM^2}$.

$SM^2 = \cdot 8^2 = \cdot 64.$ $\quad SN' = S8' + (n-8) \times \cdot 3183.$

$S8' = 2\cdot 5433 = 8 \times \cdot 31834 - \cdot 0034.$

$\therefore\ SN' = n \times \cdot 3183 - \cdot 0034.$

$\therefore\ h = \sqrt{(\cdot 3183n - \cdot 0034)^2 - \cdot 64}.$

The values of h in Column 4 are obtained by substituting different values for n in the above formula.

When it is required to draw a polygon of many sides any error in the length of 8′9′ introduced by faulty draughtsmanship will be multiplied many times when this length is stepped up SR to obtain the point N′. In such cases it is better to use the following modification of the method: With B as centre and BA as radius describe an arc cutting MP in E (see Figure 27). Mark point 12 so that E12=AB.

Then point 12 is the centre of the circumscribing circle of

a dodecagon. For ME $= \sqrt{BE^2 - BM^2} = \sqrt{AB^2 - BM^2}$ $= \sqrt{3BM^2} = \sqrt{3}$. M12 = E12 + ME = AB + $\sqrt{3}$ = 2 + $\sqrt{3}$ = cotan 15° = cotan $\frac{\pi}{12} = h$ for a polygon of 12 sides.

With S as centre and S12 as radius describe an arc cutting SR in 12′. By stepping the distance 8′12′ up SR points 16′, 20′, and so on, are obtained. Intermediate points on SR can be got by stepping the distance 8′9′ from any of the points 12′, 16′, 20′, and so on.

By using this variation of the method any error of draughtsmanship is multiplied fewer times. Figure 27 shows a polygon with twenty-two sides drawn by this method.

Note to Mr. Silver's paper "On the Construction of Regular Polygons."—By H. STANLEY REDGROVE, B.S. (Lond.), F.C.S., and W. H. COLES.

We are exceedingly glad that our paper "On the Construction of Regular Polygons" has called attention to what appears to have hitherto been a somewhat neglected mathematical problem, and has borne such excellent fruit as Mr. Silver's highly ingenious elaboration of our third method. No doubt, from a practical point of view, our original methods are to be preferred on account of their simplicity, and the exceedingly slight error occasionally introduced can be practically eliminated by adjusting the centre of the circumscribing circle as explained at the end of our paper. But, of course, Mr. Silver's construction is still more accurate, and possesses the advantage of being—what our methods are not—perfectly general. Indeed we, cannot call to mind any practical solution of a series of geometrical problems which, whilst not theoretically exact, attains the same degree of approximate accuracy as Mr. Silver's method of constructing regular polygons. We offer him our congratulations.

THE PRINCIPAL METEORIC SHOWERS.

By W. F. DENNING, F.R.A.S.

I HAVE been investigating the duration of some of the richest and best-known systems, and believe their visible activity is extended over longer periods than generally supposed. I have formed the following summary :—

Name.	Duration.	Max.	Radiant.
			° °
Boötids ...	Dec. 25–Jan. 13 ...	Jan. 3 ...	230+52
Lyrids ...	April 16–25 ...	April 21	265+33 to 276+33
Aquarids ...	April 29–May 10 ...	May 4	329−3 to 342−1
Perseids ...	June 26–Sept. 5 ...	Aug. 11–12	358+34 to 89+57
Orionids ...	Oct. 3–Nov. 7 ...	Oct. 20 ...	92+15
Leonids ...	Nov. 7–21 ...	Nov. 14–15	151+23
Andromedids	Nov. 15–24 ...	Nov. 17–21	24+43
Geminids ...	Nov. 25–Dec. 16 ...	Dec. 11	91+33 to 117+32

The Perseids appear to be in action over a longer period than any other display, having a radiant which drifts with the time.

With regard to the positions of meteoric radiants, generally they are determinable under the best conditions to within 1° probable error, but the exact durations are more difficult to obtain. The very large number of visible streams—active and feeble, and especially the latter—occasions confusion, and it is sometimes impossible to ascertain when or where one display begins and another ends. For instance, if an observer sees a streaking meteor directed straight from the Perseid radiant on August 10th, he assumes it at once to be a Perseid, but it may belong to another shower near, as there are several August radiants in Perseus.

More abundant observations of greater accuracy are needed. It is much to be regretted that photography has failed to realise expectation in this field. Fortunately an observer may, from naked-eye records, attain a degree of accuracy scarcely considered possible, and can generally found a safe judgment upon his data; but the latter will not always absolutely demonstrate the correctness of the conclusions arrived at.

Though many of the chief meteoric showers have been subject to repeated investigation, they are far from being exhaustively known. It would scarcely be believed that the question whether or not the great Leonid display presents a moving radiant is still unanswered. Yet it is a point that might be readily cleared up by a few nights' watching in a clear climate. In England the weather has often frustrated my efforts to solve the problem, and in many years the shower is scarcely to be recognised except on or very near the date of maximum.

Certain showers, though seemingly brief in their manifestation, like the Boötids and Lyrids, are not nearly so transient as appearances suggest. They have a well-pronounced activity or maximum, ranging over a few hours; but, before and after this, occasional meteors are directed from similar points in the heavens. Take the Perseids as an example. Though it affords the spectacle of a brilliant and abundant display on one or two nights only about August 11th and 12th, yet, for some weeks preceding and following this development, meteors continue to emanate from the same system, though the radiant is in daily transit of 1° to the eastward.

In the case of the Boötids, seen at the opening of the year, the maximum used to occur on January 2nd; it is now generally on January 3rd, and its richness is of very fugitive character. Meteors of similar aspect, however, continue to shoot from the same radiant certainly until January 13th, and possibly until a later date.

Multiple observations of identical meteors are extremely valuable when accurate, as they indicate beyond question the correct place of a radiant. In cases where radiants are assumed from records of meteors by one person there must always be doubts attached to them, except in those instances which are unusually well corroborated by ample data. To apply radiants for singly observed meteors is a most delicate and difficult proceeding, requiring sound judgment, based upon long experience and a consideration of all the features involved. It is not too much to say that many hundreds—if not one or two thousands—of meteoric radiants previously assigned are merely false positions which have been accepted on the chance intersection of a few tracks.

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NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

STAR-DENSITIES.—Mr. H. Shapley contributes an article to *The Astrophysical Journal* for October on the density of eclipsing variable stars whose spectrum is of the solar type. He has already deduced that the average density of Sirian stars is from 0·1 to 0·2 of the Sun's density, the least value being 0·006 for the helium star δ Orionis. He now finds the densities of five solar type stars: SX Cassiopeiae (density 0·0004), RX Cassiopeiae (density 0·0005), RZ Ophiuchi (density 0·001), RT Lacertae (density 0·013), W Crucis (density 0·00003). These stars would appear to be all giant stars, and the result supports Professor H. N. Russell's conclusion that giant stars pass through the solar type of the spectrum earlier than the Sirian one. On the other hand, he gives two stars, W Ursae Majoris and U Pegasi, whose density is comparable with that of the Sun: these are presumably dwarf stars.

Professor Eddington in an article in *Scientia* obtains three hundred million years as the time of revolution of stars about the centre of the system, assuming the star-density the same as in our neighbourhood. As he gives each star only one-third of the Sun's mass, and makes no allowance for dark stars, the actual time of revolution would be considerably less. As an illustration of the very small attraction that individual stars exercise on each other, he points out that the attraction of the Sun on α Centauri would produce, in a century, a velocity of a metre per hour. Even this small force would have sensible effects if it persisted for millions of years; but long before that the two stars will cease to be near neighbours. This example shows that the stellar movements are due to the combined attraction of the whole cluster, not to individual attractions.

Mr. L. V. King examines in *Nature* the mass of the dust or gas in space that would be required to produce the absorption effects that some astronomers have deduced from the numbers of stars of successive magnitudes, and in other ways. He reaches the startling conclusion that the mass of this scattered dust and gas is three hundred thousand times as great as the combined mass of the stars. Such a mass as this could not fail to exhibit marked effects on stellar movements, such as the observed movements fail to show. Either the total mass of dust is much less than the estimate, in which case the absorption of the light of distant stars must also fall far below the figures that have been given, or this finely divided matter does not produce the same gravitational effects as concentrated matter does. We are familiar with the fact that, in the case of the finely divided matter in comets' tails, repulsion prevails over attraction. There would seem to be a possibility that the same sort of action might take place between suns and cosmic dust, so that the gravitation effect might be neutralised, or even reversed.

LIGHT-VARIATION OF EROS.—It will be remembered that Eros has shown marked variability of light at several oppositions. Margaret Harwood, of Nantucket Maria Mitchell Association, investigated it at the opposition of 1914 by photography. She found a range of 0·4 magnitude in a period of seven hours twenty-one minutes, three times as long as that found by Bailey in 1903. As the inclination of the orbit is considerable, the disc is differently presented at different oppositions, so that we may be prepared for a different light-curve, the variation presumably arising either from spots on the surface or irregular shape of the planet. The latter is by no means improbable. There is no reason to expect a spherical form in such a small body, the diameter being about twenty miles.

MISCELLANEOUS OBSERVATIONS. — Mr. A. E. Douglass described his method of photographing the Zodiacal Light. Some of his photographs of this have already appeared in "Knowledge." He uses a large aperture and very short focus, and takes repeated exposures, combining the results into a single print; more contrast is thus obtained. He states that he has also photographed the Gegenschein.

The proper motion of the cluster Messier 37 was investigated by photography at the Yerkes Observatory. Its motion in a century relatively to the surrounding stars was found to be 0″·66 in position angle, 46°·2. The interval between the plates was eleven years, hardly enough to give the centennial motion with accuracy.

Messrs. Joel Stebbins and Jacob Kunz have been working with the photo-electric cell, which they have made so sensitive that the probable error for stars of magnitude 3½ is less than one-hundredth of a magnitude. That was the limit of magnitude for the selenium photometer; but the new cell goes down to magnitude 5. Beta Lyrae has been under observation with it, but the results are not yet fully discussed.

Another method of determining magnitudes is being used by F. C. Jordan with the Thaw refractor. He takes photographs out of focus, so the stars appear as discs. The density of the deposit on these discs gives the magnitude very exactly. RS Boötis is found to range from 9·4 to 10·8 (visual range 9·2 to 10·2). SU Draconis ranges from 8·7 to 9·9 (visual range from 8·9 to 9·6). The fact of the photographic range being greater than the visual presumably means that the stars get redder at minimum, a fact which had already been noted in some stars.

There has been wonderful progress in the accurate determination of star-magnitudes in the last twenty years, and the results are of great importance in studies of the structure of the universe.

A NEW SHORT-PERIOD COMET. — Mr. Taylor, observing near the Royal Observatory, Cape of Good Hope, found a comet of the tenth magnitude a little south of Delta Orionis. It has since then brightened up to the eighth magnitude, and moved considerably to the northward. It proves to be a short-period comet, and adds another to the numerous Jovian family. The following elements are by Messrs. Neubauer and Jeffers from observations on December 7th, 13th, and 18th.

Perihelion Passage, 1916, January 27·91, G.M.T. Omega, 352° 54′; Node, 114° 51′; Inclination, 14° 30′; Perihelion Distance, 1·520; Eccentricity, 0·5001; Period, 5·30 years. The period, if correct, is unusually short. The comet would appear to have been fairly near Jupiter at its last aphelion passage, and it is probable that its orbit then suffered considerable disturbance. The orbit shows some resemblance to that of Daniel's Comet of 1909, and it is possible that identity may be established with that comet or with some other on our lists. The position on February 9th is: Right Ascension, 5h. 29m. 0s.; North Declination, 23° 46′; Daily Motion, + 1½ min, North 22′. It will be visible in the evening sky for some months.

SEARCH FOR PLANETS OUTSIDE NEPTUNE.—Professor Lowell has published a Memoir in which he examines the deviations of Uranus from its calculated position, and endeavours to locate a planet that would produce these deviations. At first sight one might think that Neptune, not Uranus, was the planet to examine. But since 1846, when Neptune was discovered, it has described much less than its half orbit; and on so short an

arc it is impossible to say how much of the deviation is due to an unknown planet, and how much to error in the adopted orbit. The observation by Lalande in 1795 adds a little to our knowledge, but it is isolated, and too much stress should not be laid upon it. Ultimately the movements of Neptune should reveal with certainty either the presence or absence of a more distant planet; but for the present we have to use Uranus. We have observations going back to 1690, there being no fewer than nineteen before its discovery by Herschel in 1781. On arranging them in groups and taking means, the residuals from Gaillot's Tables are exhibited. With the exception of 4″ in 1752, none are greater than $2\frac{1}{2}$″, so there is no certain proof of an external planet as there was in Neptune's case. Five different hypotheses were tried as to the distance of the unknown. They range from $40\frac{1}{2}$ to $51\frac{1}{4}$ astronomical units. The possible positions of the unknown in 1914 on the different hypotheses are tabulated. They form two groups, one covering longitudes 225° to 274°, the other covering longitudes 42° to 116°. It was found impossible to determine the inclination of the unknown's orbit. Its mass is estimated as a third of Neptune's, or six times the Earth's. Its magnitude is estimated as the twelfth, or about the same as most of the minor planets that are now found. Its motion would be much slower, and it would need care to distinguish it from a star. Professor Lowell finds that there is no discontinuity in the perturbations in passing through a point where the periods of the two planets are commensurable. A considerable controversy raged on this point after the discovery of Neptune.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon), F.I.C.

GRAPHITIC ACID.—Certain preparations from graphite have been obtained which, owing to their approximate constancy of composition, have been termed "graphitic acid" and "graphitic oxide." The nature of these supposed compounds has been investigated by M. Balbiano (*Annali Chim. Applic.* 1915, IV, 231), who has prepared specimens from both natural and artificial graphite. These varied in composition between the limits represented by the formulae $C_{19}H_4O_7$ and $C_{14}H_4O_7$. When they were heated under reduced pressure they yielded carbon monoxide, carbon dioxide, and water; while at higher temperatures the water vapour acted upon the carbon, and small amounts of hydrogen and methane were formed. By treating graphitic acid with a solution of hydroxylamine in a mixture of alcohol and water, a residue consisting only of graphite and water was left. From the results of the experiments the general conclusion is drawn that these supposed chemical compounds are only adsorption compounds of graphite with water, carbon monoxide, and carbon dioxide.

SOY AND SAKÉ OILS.—The increasing demand for oils and fats for both edible and technical purposes has led to the utilisation of oils which at one time would hardly have repaid the cost of preparation. For example, oil is now extracted from the dead chrysalides of the silkworm, and various kinds of refuse materials are treated to separate any fat they contain before being thrown away. The most recent additions to the sources of oils are described by Messrs. Tsujimoto and Ueno in *The Journ. Chem. Ind. of Tokyo*, 1915, XVIII, 1072. "Soy" oil consists of a mixture of soya bean and wheat oils, and is obtained as a by-product in the brewing of soy, the yield being about 0·25 to 0·3 per cent. It is a dark red to brown liquid, with an aromatic odour of soy, and is now a recognised article of commerce used in the manufacture of soap of low grade. "Saké" oil consists mainly of rice oil, and is found floating on the surface after the fermentation of saké. The yield (0·01 to 0·02 per cent.) is much less than in the case of "soy" oil. It is an orange-yellow liquid with a characteristic odour recalling saké. It has not yet become a commercial article.

THE POTASH PROBLEM.—A recent *U.S. Commercial Report* (No. 253) deals with the ways by which the dearth of potash in North America might be supplied. The difficulties of utilising felspar as a source of potash may possibly be surmounted by a process recently patented by a Canadian. The felspar is heated to about 1200° C. with limestone and iron oxide, in order to obtain a semi-fused mass, from which it is claimed that the potassium salts may be extracted by means of a dilute acid.

The U.S. Geological Survey suggests the possibility of extracting the potash from the refuse, or "tailings," which accumulate in vast quantities at the concentration mills of the large copper mines in the Western States. The ores worked in these mines contain more potash than copper, and this accumulates in the tailings in the form of potassium silicate. It is estimated that sufficient potash might be obtained from this source to supply the whole of the American demand.

GEOGRAPHY.

By ALEXANDER SCOTT, M.A., B.Sc.

THE GLACIAL-CONTROL THEORY OF CORAL REEFS.—This theory, which was first proposed by Belt in 1874, and discussed by Upham (1878), Penck (1894), and Daly (1910), has recently been the subject of a long paper by the last-mentioned author (*Proc. Amer. Acad. Sci.*, November, 1915). It is assumed that since Archean times the ocean-floors have remained steady, so that the volcanic masses of the Pacific had been reduced in pre-Glacial times to plateaux, either by marine erosion or subaerial denudation; and, further, that, at the beginning of the Glacial period, atolls were growing on these platforms. The formation of the ice-sheets would be accompanied by a diminution in the amount of sea-water, and hence by a general lowering of sea-level, while the temperature of the ocean would also tend to fall. The reefs would then be eroded down to form platforms, on which, when the ocean-level rose and the temperature increased, at the end of Glacial times, reefs would re-form round the edge of the platforms as barrier reefs.

In a paper in the *American Journal of Science* Professor W. M. Davies offers several criticisms of this theory. In the first place, there is no evidence that the ocean-floor has remained in such stability since early Palaeozoic times, nor has the existence of any such eroded volcanic mass ever been verified. The lack of uniformity in and the varying depths of the lagoon floor are also arguments against the theory. Further, such evidence as we have is not in favour of the idea that in Glacial times there was a total inhibition of reef growth, due to corals. In this connection, while many widely separated localities show signs of glaciation, it is difficult to believe that these glaciations were contemporaneous. Davis (see "KNOWLEDGE," September, 1915) concludes in favour of Darwin's theory, and shows that it is not incompatible with sea-level oscillations during the Glacial period, for these may be due, not only to meteorological conditions, but also to local subsidence and more widespread movements of the ocean-floor.

GEOLOGY.

By G. W. TYRRELL, F.G.S., A.R.C.S.

FOSSIL MICRO-ORGANISMS.—The activity of micro-organisms in the formation of certain rocks, such as bog iron-ore and travertine, is well established; but the preservation of such organisms as fossils, and still more their certain identification, has presented much difficulty. Dr. David Ellis, however, has recently published a paper on "Fossil Micro-organisms from the Jurassic and Cretaceous Rocks of Great Britain" (*Proc. Roy. Soc.*, Edinburgh, 1915), in which he claims to have discovered and identified fossil fungi in certain oolitic ironstones, and fossil bacteria in a nodule from the Gault of Folkestone. The beautiful micro-

photographs which illustrate this paper seem to render this claim almost indisputable. Of these micro-organisms only one—a fungus (*Phycomycetes frodinghamii*)—is deemed sufficiently well preserved to have a generic and specific name assigned to it. It adds one to five other complete accounts of fossil fungi by other authors. The organism was found in the Frodingham ironstone of the Lower Lias of Lincolnshire. The hyphae, sporangia, and spores were observed, and Dr. Ellis believes that the fungus possessed a chemiotactic affinity for iron salts, such as is at present known to be possessed only by certain bacteria and algae and that, like these organisms, it may have been an agent in the precipitation of iron ores, although not likely to have built up the entire rock.

With regard to bacteria, Renault found that the rod-like forms, Bacillus or Pseudomonas, predominated in the vessels of fossil trunks of cycads and other plants, and in the interior of coprolites; and among them, in subordinate numbers, were the round forms of the Coccus group. Dr. Ellis supports these identifications, and adds other examples, both of the rodded and round forms, from a Gault nodule. The preservation of these organisms is so excellent that he has no doubt whatever in assigning them to the bacteria.

THE SKULL AND JAW OF PILTDOWN MAN.—The remarkable find at Piltdown is the subject of an interesting discussion by an American zoölogist, G. S. Miller, junior (*Smithsonian Miscellaneous Collections*, Volume LXV, 1915), who especially criticises the current view that the jaw and the skull belong to the same individual. His contention is that the skull is so distinctively human, and the jaw so distinctively simian, that they could not possibly have been united in the same individual. This opinion, however, was more widely held by eminent palaeontologists and anatomists in the earlier stages of the investigation of these remains. Mr. Miller has had access to a set of casts of the Piltdown fossils, and has paid especial attention to the mandible, which he has compared with that of a large number of chimpanzees, gorillas, and orangs. As a result of this study he finds that the characteristics of the skull and jaw are in marked contrast. The skull shows the fundamental characters not hitherto known except in members of the genus *Homo*. The mandible, two lower molars, and an upper canine show equally diagnostic characters hitherto unknown except in members of the genus *Pan* (chimpanzee). There is no trace of blending of the two sets of characters, as might be expected if the remains were those of a creature in which the characters of the face, brain-case, jaw, and teeth were so generalised as to represent a structure that could have given rise to the distinguishing features of both man and chimpanzee. The assumption that the remains belonged respectively to a man and a chimpanzee causes only two difficulties: (*a*) The deposition within a few feet of one another of remains rarely found in gravel pits; and (*b*) the supposed absence of chimpanzee remains from the European Pleistocene faunas. Mr. Miller says, however, that the conditions causing the deposition of one specimen in a certain spot might equally act in the same manner with another (*e.g.*, remains of all sorts within a certain area might be swept indifferently together by a particular current). The second objection is negative, and may be nullified any time by the discovery of chimpanzee remains. Furthermore, a tooth, indistinguishable from the first lower molar of a chimpanzee, has been described from the Pleistocene of Germany. With the acceptance of these conclusions the Piltdown mandible and teeth become representative of a new species of chimpanzee (*Pan vetus*), differing slightly from the existing African species.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

CURIOUS APPEARANCE DUE TO FOG.—An extremely dense fog prevailed in London on Saturday morning, October 30th, and the fog also covered the suburban districts. About 11 a.m., as it seemed to be inclined to dissipate, I went out from Dulwich Wood Park to Upper Norwood. On reaching the higher ground the sun slightly broke through the fog, and by the time I arrived at the south end of the Crystal Palace Parade it was shining on the Palace. On walking along the Parade I was much struck by the unusual appearance of the Crystal Palace, for the Centre Transept and the North Tower stood out very much larger, clearer, and softer than I had ever seen them before. They seemed to be very near, and every part was most sharply defined. I was so much impressed by this peculiar appearance that I went back along the Parade in order to watch this remarkable phenomenon and to make sure that I had not been deceived over it. About an hour later I returned along the Parade, when the fog had cleared away from the high ground, and there was a slight wind movement, but the appearance of the Palace was then quite normal.

On one or two subsequent occasions I have noticed a somewhat similar appearance of the Crystal Palace, but it was not quite so marked as on October 30th. There was only very slight fog on these occasions. I suppose this peculiar appearance of nearness and largeness was due to the increased size of the water particles in the fog.

AWARD OF THE SYMONS GOLD MEDAL.—The Council of the Royal Meteorological Society have awarded the Symons Gold Medal for 1916 to Dr. Charles Alfred Angot, the Director of the Bureau Central Météorologique de France, in recognition of the distinguished work which he has done in connection with meteorological science. The medal, which is awarded biennially, was founded in 1901 in memory of the late Mr. G. J. Symons, F.R.S., the originator of the British Rainfall Organisation. The former recipients of the medal have been: Dr. Alexander Buchan, F.R.S., in 1902; Dr. Julius Hann, of Vienna in 1904; Lieut.-General Sir Richard Strachey, F.R.S., in 1906; M. L. Teisserenc de Bort, of Paris, in 1908; Sir Napier Shaw, F.R.S., in 1910; Professor Cleveland Abbe, of Washington, in 1912; and Mr. W. H. Dines, F.R.S., in 1914.

The medal was presented at the annual meeting of the Royal Meteorological Society on January 19th.

THE CLIMATE OF NEW ZEALAND.—Mr. D. C. Bates, the Dominion Meteorologist, has given in *The New Zealand Year Book* a succinct account of the climate and meteorology of New Zealand. Particulars are given of the temperature, rainfall, sunshine, winds, weather, etc., at representative places in the North and South Islands. Speaking of the general effects of the climate, Mr. Bates says that the development of the Maori race is a striking testimony to the suitability of the climate to humanity, and European families under New Zealand skies have generally developed in physique. Imported stock has in most cases thriven marvellously in the fields, where throughout summer and winter they usually find all the nourishment needed, and hardly ever require more than natural protection. The fertility of the soil gives remarkable testimony to the genial climate of New Zealand; for, though labour is not nearly plentiful enough to obtain the best results from agriculture, yet, as shown in the returns published annually, the actual average yields in bushels per acre for the Dominion compare more than favourably with the yields for other countries. Furthermore, the vital statistics show that for a long period New Zealand has had the lowest death-rate in the world, and this is undoubtedly owing very much to the salubrity of its climate. The vital statistics show to advantage, not only in the earlier years of life, but it is after the age of thirty-two that the extraordinary longevity of New Zealand is apparent. The abundant vitality of the people is apparent, not only in the homes and thoroughfares throughout the Dominion, but is manifested in thriving industries and the high place attained by New Zealanders in the world of sport. New Zealand, in

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a word, is stated to be a country where, from youth to old age, man can keep in vigorous health and enjoy life to its fullest extent.

MICROSCOPY.

By F.R.M.S.

NEST OF THE MASON BEE (*CHALICODOMA MURARIA*).—It is interesting to note that the photographs reproduced in Figures 28 and 29 show almost the whole history of the life of the mason bee. For we have the whole nest of cells, which are made up of fine grains of sand in rings round the cells, which are made of earth, while the cells are very carefully smoothed on the inside. In some of these cells are to be seen the grubs fully grown; in others the pollen, ready for the tiny grub to feed on when it hatches. Then there is the pupa, in its shining skin-case; and, last but not least, the perfect insect.

The nest was built on the top of the pedestal of the sun-dial, between it and the under-surface of the dial. I should say the pillar is an iron column, made to carry a small equatorial telescope, so that it has a projecting ring, three-eighths of an inch deep, for the mount to work on; and it was inside this ring that the bees made their cells, the bottom of the cells resting on the iron plate, and the top covered by the bottom of the slate dial.* You will see a flat space at the bottom of Figure 28, and this was the entrance to the cells. The pillar stands on a square stone base, being three and a half feet high; and the dial is ten inches in diameter. The space for the nest was three-eighths of an inch by a diameter of six inches, which was quite filled with the cells. The dial had been standing some seven years, the ants having worked out all the cement that fixed the iron pillar to the stone; so it was necessary to refix it, and on taking off the dial this wonderful nest was discovered.

With reference to the bee, I had seen several small bees about, and, when near the dial, they would fly round, making a buzzing noise, and settle on the dial, laying themselves flat on the surface. They were only to be seen when the sun was shining.

I have not been able to distinguish the male from the female, but of the two specimens shown in Figure 29, the head is black, covered with hair; the thorax grey, covered with a large tuft of hair; the two fore-legs are short and covered with long hair, also the middle pair. The hind pair of legs are covered with the same-coloured hairs as on the abdomen, which is yellowish brown.

As the dial has been refixed I hope next summer to be able to study the habits of this most interesting insect. I can find but very little written about this little bee. Réaumur, indeed (1683–1757), ascertained that every individual grain of sand is moistened previous to its being joined to the pellet in order to make it adhere more effectually. The tenacity of the mass is, besides, rendered stronger, he tells, by adding a proportion of earth or garden mould. In this manner a ball of mortar is formed, about the size of a small shot, and carried off to the nest. When the structure is examined, it has the appearance, externally, of being composed of earth and small stones, or gravel.

The ancients, who were by no means accurate naturalists, having observed bees carrying pellets of earth and small stones, supposed that they employed these to add to their weight in order to steady their flight when impeded with the wind.

THOS. E. FRESHWATER, F.R.M.S.,
Past President Photomicrographic Society.

INTELLIGENCE IN PARASITIC ROTIFERS. III.—In my last communication (May, 1914) on this subject I sketched the behaviour of the two small species which take board and lodging with the passive but friendly *Volvox globator*.

The subject of the present example of intellect in these mighty atoms shows a more aggressive and fighting nature, a kind of war hero suitable for recommendation for the Military Cross. Owing to its diminutive size, it is not a conspicuous creature, and is not often met with, but it has been observed on various occasions by a number of observers, mostly students of rhizopods, such as Archer, Leidy, Stokes, and on the last occasion by Dr. E. Pénard, of Geneva, from whose combined observations the following account is extracted.

The *dramatis personae* are the following: (1) A freshwater rhizopod of the heliozoid profession, about 250 μ in size, oval in shape, and covered with a shield of minute flat plates of silica protected by a forest of spikes, bifurcate at their ends, which surround it on all sides, named *Acanthocystis turfacea*. (2) A small notommatoid rotifer, elongate and rounded in shape, about a third the size of the heliozoid, provided with a sort of electric-fan arrangement in front, made of cilia, for attracting food-particles and for swimming, and possessing two small stout toes, which can serve as levers or crowbars when occasion demands; a roving pirate by profession, about 90 μ in size, to which the name of *Proales latrunculus* has been given.

The scene is a freshwater bog pool in the summer of any year, where heliozoa love to make their home. The "pirate" is rarely seen, and none of the observers named have met with it for certain in its free-swimming, roving state, but the presence of *Acanthocystis* is sure to attract it to the scene.

When first seen, the little rotifer was found inside the heliozoan, and in order to account for its getting there Dr. Pénard can only conjecture that it swam full-tilt against and charged the rhizopod (three times as large as itself), and then remained perfectly quiet whilst the latter extended protoplasmic pseudopodia, and drew it in through the protecting armour. This is quite the usual way *Acanthocystis* deals with ciliated infusoria when they chance to meet and run against it in their wanderings; the plates and needle-like spikes separate, a stream of protoplasmic pseudopodium is extruded towards the guest, surrounds and engulfs it, and draws it in to be incorporated with its store of food-material. The needles and plates then return to their former positions as if nothing had happened. What then takes place between the rhizopod and rotifer cannot fail to interest, and is best stated by the American observer, Dr. A. C. Stokes, in his own accurate, though perhaps not in a particularly severe scientific, style as follows:—

"Recently one of these spinous creatures (*Acanthocystis*) appeared under my microscope. It seemed to be alive and well, but within it, near the armoured surface, was a semi-transparent moving something that was too active to have a right there. As the motions of this foreign body became more impulsive, it turned completely over, and showed itself to be one of the rotifers. In size it equalled not more than a third the *Acanthocystis*' diameter, but dwarfish stature was amply compensated by nimbleness.

"With a leap, prodigious for so small a creature, the rotifer dashed against the wall and hurled the rhizopod down the field, while the silicious spines snapped and flew. If the scene was exciting to the spectator, what must it have been to the *Acanthocystis*, with that jumping Jonah leaping among its vitals! It was no joke to either party. A struggle for life was going on under my very eyes. The rhizopod, with every particle of its jelly-mass surrounding the rotifer possessing digestive power, seemed calm, perhaps with the calmness of despair; but the rotifer—oh! how she plunged. Not a moment did she rest; not a muscle did she leave unused; not a manœuvre untried. The situation appeared a bad one for that rotifer, since she bade fair to be digested. She stretched herself, and forced

* I might say that the contents of the nest were dead, I think, owing to my having painted the pedestal in the summer, while the bees were busy with their work.

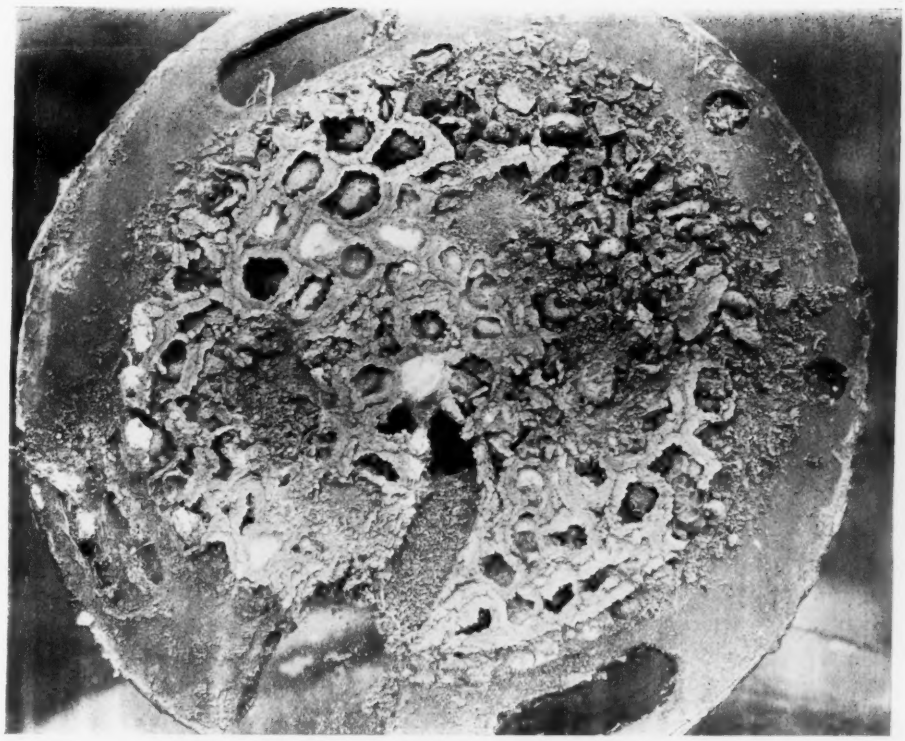

FIGURE 28. The Nest of the Mason Bee.

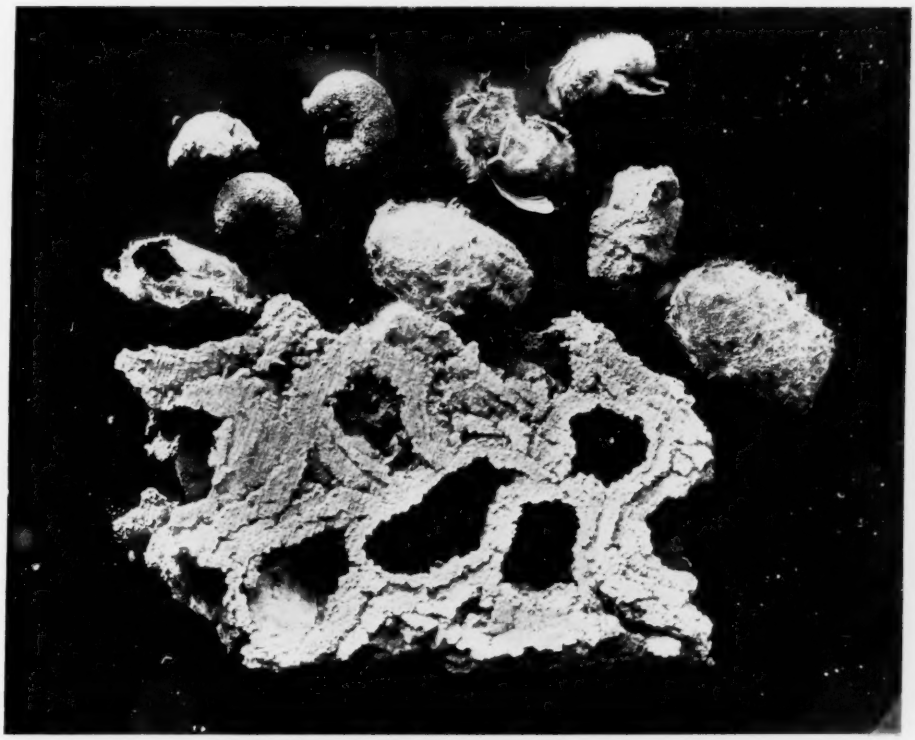

FIGURE 29. Cells, grubs, and full-grown examples of the Mason Bee.

FIGURE 30.
A rotifer (*Proales latrunculus*).

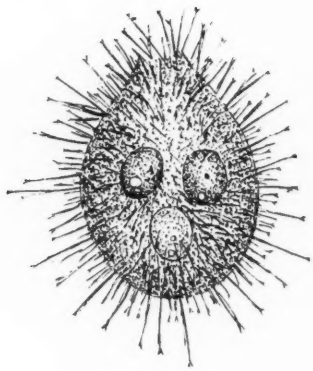

FIGURE 31.
Acanthocystes turfacea, in which the rotifer has left 3 eggs.

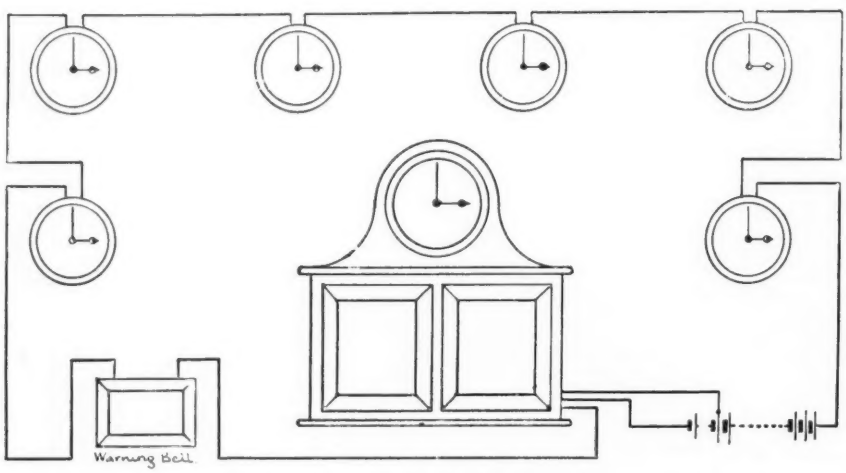

FIGURE 32. Circuit of Pulsynetic Clocks for steamship use, employing a balance wheel and hair-spring.

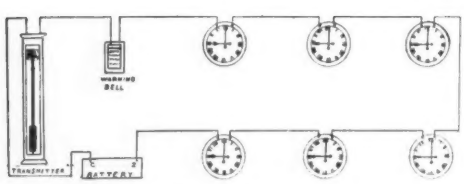

FIGURE 33.
Circuit of Pulsynetic Clocks for land use. These employ a pendulum in the master clock.

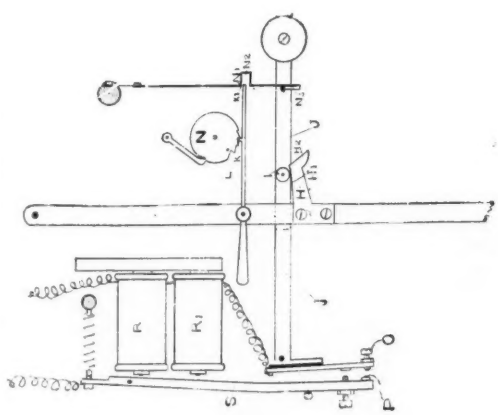

FIGURE 34.
Diagram showing action of Transmitter for land use.

(See page 49.)

out the spinous armour until it seemed on the point of rupture; the *Acanthocystis* simply flattened the opposite side and waited, digesting. The rotifer leaped; she turned; she pushed with her two sharp toes against the wall. The rhizopod rolled over the field, the spines were loosened and fell off; yet the rotifer remained in the corner where she first appeared, pressed down by the *Acanthocystis'* body-mass, although her efforts were continually nothing less than frantic. For six hours the struggle lasted; from fourteen to twenty o'clock the microscopic creatures were under uninterrupted observation. Finally, after a short rest on the rotifer's part, there occurred one of the most amusing exhibitions of intelligence in these lowly organisms that I have ever seen. It was, indeed, a most masterly piece of strategy. *The rotifer began to eat!* Protoplasmic jelly, chlorophyll-corpuscles, half-digested food-particles—everything the *Acanthocystis* contained streamed down into the rotifer's transparent stomach. With short intervals, which she improved by butting against the wall, she ate until she arrived at the central nucleus, when, apparently perceiving that the object was accomplished, she stopped, and then—it really did seem as if she was celebrating her victory—she laid an egg!

"The rhizopod once dead and half empty, the brave rotifer selected the spot at which she intended to leave, and left. It is a curious fact that, having chosen the place for exit, she continued to beat against that point only, until the basal plates were forced aside and she was free. Circling once or twice around the dead *Acanthocystis*, she darted from the field, followed by applause and a few remarks of approval from the spectator.

"By twenty-four o'clock the ovum that had been extruded in my presence, as well as in prison, which I had seen rolling down the half-empty *Acanthocystis'* sac, had accomplished a part of its internal changes, but an awkward movement displaced the cover-glass and ruined all.

"Did that unhappy rhizopod in an absent-minded moment take in an egg, and did that egg eventually take in the rhizopod?"

Dr. Stokes does not supply the answer to this question. One can only hear his exclamation: "Bravo! little rotifer." Nor did Dr. Pénard, although he had numerous opportunities of observing the little pirate, succeed in furnishing a definite and conclusive account of the rotifer's entry into the heliozoon. He saw a number of individual combats, which nearly always ended in the defeat and death of the rhizopod, and in the victory of the smaller, more vigorous, and more intellectual rotifer. The *Acanthocystis* tried all kinds of tricks to get the upper hand, such as the secreting of a larger volume of digestive fluid; or, by contracting its plasma, it pressed the intruder into a corner, and then tried to squeeze off that part of its body-wall, thus leaving the "wild beast" behind in an empty cage, whilst the rhizopod, escaped. One individual, indeed, succeeded in forcing its unwelcome host through an anterior opening, together with part of the contents of its body-cavity and plasma, and was afterwards seen at some little distance recovering with much diminished body-substance. Such results of the fight were, however, exceptions, and not the rule.

If Dr. Pénard is correct in his supposition, the account supplies a most extraordinary case of intelligence, forethought, and even strategy. Here we have a speck of a rotifer, the $\frac{1}{200}$th part of an inch in size, first allowing itself to be eaten and taken inside an armed and well-defended fortress, and then assailing it from the inside; and, when this does not succeed at once, weakening the master of the castle, and depriving him of his food-supply by the simple plan of consuming it himself, and refusing all the time to be digested!

This is not a romance from the "Arabian Nights," but facts which can be watched under a microscope. The only point which remains doubtful is the manner by which the rotifer gains access in the first instance to the interior of the rhizopod. Everything else has been proved by repeated observations.

In one season Dr. Pénard noted that nearly half the *Acanthocystis* of the bog pool was attacked by this small parasitic rotifer, so that there existed a real rotifer plague, from the rhizopodian point of view. In some cases as many as six to seven eggs were found deposited in one heliozoan, but the more usual number was two to three.

The accompanying figures show (Figure 31) *Acanthocystis turfacea*, after the rotifer has made its escape, leaving three eggs behind; and Figure 30 represents *Proales latrunculus*, the pirate and hero of the adventure, showing its jaws, brain with red eyespot, intestine, ovary, foot-glands, and pointed toes.

Anyone, therefore, desiring an exciting half-day of microscopical study, together with a lesson in pluck and strategy, cannot do better than capture at the right season (June to September) one of those hairy infusorians with a rotifer (or its egg) inside, and watch the events which will follow as a matter of course.

CHARLES F. ROUSSELET, F.R.M.S.

THE QUEKETT MICROSCOPICAL CLUB.—The five hundred and twelfth ordinary meeting was held on Tuesday, December 28th, 1915, at 20, Hanover Square, W. Vice-President C. F. Rousselet, F.R.M.S., in the chair.

After the usual business of an ordinary meeting, Mr. J. T. Cook exhibited and described a pond-life trough which he had designed and found very successful. It may be constructed with advantage of the $3'' \times 1''$ slips commonly used in microscopical work. Two slips should be taken, and between them an india-rubber ring—such as is used for putting round papers—is to be enclosed, the ends of the slips then being gripped together by a piece of hard wood in which a groove has been cut. Mahogany answers well; the groove should be about three-eighths of an inch deep, and of such width that the glass is pressed slightly against the rubber, and so prevents leakage. The troughs can be made of any size and depth desired to suit various requirements. Mr. Cook pointed out that, among other advantages, they are so simple in construction that anyone can make them. They cost almost nothing; they can be taken to pieces, and the glasses cleaned and replaced without trouble or danger of breaking; and they do not wear out. He had often kept organisms in them for observation for many weeks, filling up with water as necessary. Several members spoke in appreciation of the contrivance, and a vote of thanks was passed to Mr. Cook for bringing the matter forward.

Mr. J. Burton read a short paper "On a Species of Aleurodes Fly." The Cambridge Natural History definition of the family is: "Minute insects with four mealy wings, seven jointed antennae, two-jointed feet, terminating in two claws and a third process." It is placed between the aphides and the scale insects. The subject had been brought before the club by Mr. R. T. Lewis in 1895, when he read a paper on a new species which had been found in Natal, and was named *Aleurodes asparagi*. The paper and illustrating plates will be found in Volume VI, Series 2, of *The Quekett Microscopical Club Journal*. The species—probably *A. brassicae*—spoken of on this occasion occurred in the autumn on a fuchsia growing in a sitting-room. All stages of the insect were seen. The egg is cylindrical, with rounded ends, pale yellow. The young larvae have six legs, antennae, and two pink eyes. The segmented body has some long hairs projecting from the sides. It has a sucking proboscis, similar to that of the green flies, and very soon settles down on a leaf, inserting its sucker. It changes its skin several times, and, losing its legs, does not again move. It then closely resembles a scale insect. The pupa is very transparent, and has some long, brittle, glass-like hairs on the back and sides, and a fringe

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of shorter, more curved hairs round the upper edge of the box-like case. As development goes on, the fly can be seen forming inside. The imago is a very small and fragile creature, about one millimetre long, with four wings, in most species without nervures. The two basal joints of the antennae are larger than the others. There are two oval, pink, compound eyes, each constricted somewhat about the middle, and two small simple eyes. The legs and feet are slender; the tarsus two-jointed, with two claws, and a process between them. Under the head is a blade-like sucking rostrum, with a sharp, dark point. The whole of the insect is covered thickly with a white meal-like dust, and forms a beautiful object for the microscope. It excretes a considerable quantity of honeydew. Besides the damage caused by the larva and fly sucking the juices of the plants they infest, a fungus flourishes upon the honeydew excreted and does further mischief. Aleurodes has been the cause of serious loss to the citrus-growers in Florida, almost half the farms being infested with it, and often losing from forty to fifty per cent. of their crop. So serious did the pest become that the American Congress voted a sum of money, and a commission was appointed to discover, if possible, a parasitical insect which would prey upon the fly and destroy it. A hymenopterous parasite and a kind of ladybird were found in India, which had had some beneficial effect there, and great efforts were made to introduce these into Florida, but so far without success.

A mounted Aleurodes fly was shown under a microscope, as well as specimens of pupae, and an example of the fungus which grows upon honeydew.

Besides the paper on Aleurodes by Mr. Lewis, already referred to, there is a short article in Volume VI of the Cambridge Natural History. There is a paragraph giving a condensed life-history of the fly in No. 11 of *The Journal of Micrology*, with an excellent drawing of the imago. An interesting and detailed account of the efforts made to discover a preventive of the pest will be found in "Insects and Man," published last year.

The meeting passed a vote of thanks to Mr. Burton for his communication.

J. B.

PHOTOGRAPHY.

By EDGAR SENIOR.

VARIATION OF TONE OBTAINABLE IN COLLODION TRANSPARENCIES.—Although many of the best judges consider that transparencies made upon collodio-bromide plates are superior in quality to those obtainable with gelatine plates, few amateurs of the present day employ the former process in any form, though it is still in use by professionals and those who make lantern slides on a commercial scale. The greater sensitiveness of the gelatine plate is, of course, greatly in its favour for camera work, but for contact printing this advantage is not so marked; in fact, the very slowness of collodion dry plates is by some considered to be in their favour. That very fine results are to be obtained on gelatine plates cannot be denied, but it is difficult with a bromide plate to produce any variation in tone from a black. With some plates, but not all, very fine warm tones can be produced by the use of meta-bisulphate of potash in the developer; but black is the usual tone, and for many purposes this is as good as any, although it is not to be compared with a rich brown or purple, especially for lantern slides. But, whatever gelatine plates will do in the way of rich black tones, collodio-bromide will do equally well, with the further advantage that almost any tone, from a pure black to cherry red, can be obtained by its means with equal facility; and an additional point in favour of collodion is that less care is required than with gelatine to preserve the purity of the lights; while, if the colour of the image is not agreeable, it may be toned by various methods more readily than is the case when gelatine is the medium in which the image is formed. The question of colour has to be considered from two points of view, since it can be varied by development pure and simple, or by the subsequent application of a toning solution. Even with wet collodion plates, slight modification of the developer, together with variation in exposure, will often alter the colour of the image in a remarkable degree; while special kinds of collodion will still further modify it. Thus pyro and iron developers produce different tones, and so will alterations in the quantity or nature of the restraining acid; in fact, quite a number of methods are known to those acquainted with wet-plate photography, by which almost any colour may be produced. But for variation of tone or "colour" obtained by development alone no process can compare with collodio-bromide used dry, whether the plates are prepared by sensitising in a strong silver bath, or the silver salt is emulsified in the collodion. This was one of the features of the tannin process introduced many years ago by Major Russell, the tannin which was used as a preservative so modifying the colour that red tones could be obtained; while coffee used in a similar manner gave rise to the production of warm brown colours. With some emulsions, when a full exposure to a strong source of light is given, an image may be obtained by development alone, which is a bright "cherry" red in colour, and which may be afterwards toned with gold in the same manner as a P.O.P. print, and which will pass through the same range of tones. Under-exposure must be carefully avoided with collodio-bromide, as any forcing in development is fatal to good results. A full exposure in a strong light is what is required, as a much longer exposure in a weak light will not produce the same effect. For transparencies magnesium light is very satisfactory, as it will result in a much warmer tone being obtained, the exposure being so regulated that development is complete in about one minute. A considerable amount of over-exposure can, however, be readily controlled by washing away the developer as soon as all detail is out, and then gaining the required density by redevelopment with an acid-reducing agent and silver nitrate. This method appears to be preferable to adding more bromide which in many cases produces a hard result. For development alkaline pyrogallol is the best all-round developer for collodio-bromide plates. With it colours ranging from a warm black to a red may be readily obtained with prolonged exposure in a brilliant light. The following formula will be found a suitable one:—

(1)

Pyro	5 grains
Soda sulphite	20 ,,
Citric acid	13 ,,
Water to	2 ounces

(2)

Ammonium carbonate	8 grains
Potassium carbonate	8 ,,
Sodium sulphite	12 ,,
Water to	2 ounces

(3)

Potassium bromide	24 grains
Water to	2 ounces

For development equal parts of each are taken. If the exposure has been too long, the developer should be washed off as soon as all the detail has appeared in the image, and the following solution applied to the plate, with a few drops of a two-per-cent. solution of silver nitrate, until sufficient density is gained:—

Pyro	2 grains
Citric acid	2 to 4 ,,
Water	1 ounce

After intensification and washing the image may be fixed with "hypo" or potassium cyanide (twenty-five grains to the ounce). Some workers prefer the latter, but it must be washed away directly the whole of the unaltered silver bromide is removed, or the delicate half-tones of the image will be attacked. After fixing, washing for a few minutes in running water is quite sufficient, and the trans-

parency may then be dried spontaneously, or the drying may be accelerated by means of heat. Lantern slides made upon collodio-bromide emulsion do not usually require any after-treatment, but when the colour is not considered good they may be toned. Thus a slide which is considered too red may be toned with platinum and gold; a warm brown may be imparted to the image by means of a weak solution of ammonium sulphide, and so on. Some of the best tones, however, are got by means of silver intensification, and in the earlier days of collodion dry plates the practice invariably adopted was to produce an extremely thin image by development with pyro and ammonia, and then to intensify this with pyro and silver. By increasing the exposure, or by reducing the quantity of silver nitrate in the intensifying solution, the final image assumed a proportionately warmer tint; while by the use of acetic, citric, or formic acid, or a combination of these, colours varying from purple to brown were obtained. But when the desired tone is not secured at first, then the various toning methods become useful; and with collodion they are perfectly safe, which is more than can be said in the case of gelatine. For the production of black tones on collodion emulsion an eikonogen developer is very good, and may be prepared according to the following formula:—

Eikonogen	12 grains
Sodium sulphite	46 ,,
Potassium carbonate	20 ,,
Water	1 ounce

As a rule, before commencing to develop a collodio-bromide plate it should be soaked in a bath composed of equal parts of alcohol and water, and then rinsed under the tap until all greasiness has disappeared. The plate may then be held between the finger and the thumb, and the image developed by pouring the developer over, and working it round in a circular manner. The image will quickly appear, and grow in density until full opacity is obtained. Care, however, must be taken to guard against excessive density, as the image loses very little in the fixing bath.

PHYSICS.

By J. H. VINCENT, M.A., D.Sc., A.R.C.S.

A NEW ELECTRIC LAMP.—Gimingham and Mullard describe a new form of enclosed arc lamp in *The Journal of the Institution of Electrical Engineers* for December, 1915. The arc plays between tungsten electrodes, and is entirely enclosed in a bulb like that of an ordinary glow-lamp, the space being filled with nitrogen, as in the newest type of incandescent lamp. The arc may be maintained by either direct or alternating current. The devices for striking the arc are very ingenious, and involve the utilisation of the thermionic current, due to the heating of a refractory filament. The efficiency of the new lamp is high; and, since the light comes from a small surface, it will probably be very useful for optical projection.

IONISATION IN THE UPPER LAYERS OF THE ATMOSPHERE.—The conductivity for electricity of the air in the higher regions of the atmosphere is due, according to Nagaoka, to the effect of the ultra-violet light from the Sun and to the stream of negative corpuscles also proceeding from the Sun. These electrons are influenced in direction by the magnetic fields of the Earth and Sun, and account for the ionisation of the upper atmosphere at night. This theory is capable of explaining some of the peculiar relations between daylight and the facility of transmission of wireless messages (*Revue générale des Sciences*, October 30th, 1915.)

FARADAY'S MANUSCRIPTS.—Mr. D. J. Blaikley has presented in trust to the Institution of Electrical Engineers a valuable collection of books and manuscripts belonging to Faraday. The books include Faraday's Journal of his tour with Sir Humphry Davy, various notebooks, autograph letters, letters to Faraday from scientific men abroad, and from Kelvin, Clerk Maxwell, Morse, and many other well-known workers in this country.

Mr. Mordey has also presented to the Institution a manuscript book of extracts, which Faraday made from various works in 1809–10 when he was apprenticed to a bookbinder, and a piece of the "heavy glass" with which Faraday, in 1845, made his magneto-optic experiments, demonstrating the connection between light and magnetism by a rotation of the plane of polarisation in a magnetic field, and with which he also discovered diamagnetism.

THE NEWTONIAN CONSTANT OF GRAVITATION AS AFFECTED BY TEMPERATURE.—At the meeting of the Royal Society on December 2nd, 1915, P. E. Shaw presented a paper in which it is claimed that consistent evidence has been obtained of a temperature effect in gravitation. This has been the object of many researches in the past, and experimenters have always found that G—the Newtonian constant of gravitation—is a constant, being independent of the temperature or nature of the attracting masses. Shaw found it possible to obtain consistent cyclic readings in a gravitational experiment of the Cavendish type, even though the large masses are maintained for hours above 200° C., while the small masses remain at ordinary temperatures, and to carry on this investigation in the centre of a city at any time by day or night, in spite of tremors and the special disadvantages of having the torsion balance in a vacuum. Shaw found that when one large mass attracts a small one the gravitative force between them increases by about one part in five hundred, as the temperature rises two hundred degrees centigrade.

ELECTROLYTIC DEPOSITION OF COBALT.—From investigations on electroplating with cobalt carried out under the auspices of the Canadian Government, it appears that cobalt will speedily become a successful rival to nickel. The electrolytic solution may be that of cobalt ammonium sulphate in water, or of cobalt sulphate, sodium chloride, and boric acid in water. Cobalt plates from these solutions, of proper concentration, on metals which it is now the custom to plate with nickel. The surface takes a good polish. Finished articles have a white brilliant lustre with a slightly bluish tint. Both these baths possess properties which allow the possible rate of deposition to be several times as rapid as in the case of the commercial nickel plating baths. The cobalt coating is harder than nickel, and is much superior in protecting power to a nickel coating of the same thickness.

RADIO-ACTIVITY.

By ALEXANDER FLECK, B.Sc.

RELATION BETWEEN ATOMIC WEIGHTS AND RANGE OF α PARTICLES.—In the issue of *Nature* for January 20th, 1916, Mr. Carruthers writes to point out that if the members which emit α rays of any series of isotopic elements are considered, and if the logarithms of their atomic weights are plotted against the logarithms of the ranges of their α particles, then the curve so obtained is a straight line. He further points out that the straight lines so obtained are approximately parallel to one another, and equally spaced.

This is a very interesting relation, but when examined in detail it does not hold as generally as one would expect that it should, if there is some deep-seated theoretical considerations involved. For instance, the Geiger-Nuttall relation is valid, with only one clear exception.

There are six series of isotopic elements of which the members emit α rays, and, for the moment, we may leave for special consideration the actinium elements. Group VI-B consists of radium-A, radium-C′, radium-F, thorium-A′ and thorium-C′, and it is quickly seen that four of the points obtained for these elements lie approximately, on a straight line. The fifth, radium-F (polonium) is very far removed from this line.

The lines connecting up the points of the groups V-B, O,

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II-A, and IV-A are approximately parallel to one another.

In group VI-A there are only two elements, uranium-1 and uranium-2, and the line joining their two points is by no means parallel to the lines already obtained.

When the actinium series is considered, we are faced with the difficulty that the atomic weight of the parent element is not definitely known, although it is probably either 230 or 226. If we assume the lower value, the points for radio-actinium, actinium emanation, actinium-A, and Actinium-C, lie on lines already obtained for thorium and radium elements. The points for actinium-X and actinium-C′ are removed from the lines of their respective groups. If the higher value of the parent element is assumed, the point for actinium-C′ is on the line already obtained, while the point for actinium X is still as far removed from the line as when the lower value was taken, but on the other side of it.

RECOIL OF RADIUM-D FROM RADIUM-C.—Attention was directed in a recent number of "KNOWLEDGE" to the detection of the recoil of radium-B from radium-A by photographic means. In this case the recoiled particles did not themselves make an impression on the photographic plate: this was produced by the α rays resulting from the products of radium-B. In the December, 1915, number of the *Philosophical Magazine*, Wood and Makower described experiments which detected on a photographic plate the radium-D atoms recoiled from radium-C. The experiments were made with the same apparatus which was used for the recoil from radium-A.

The position of the impression on the plate showed that, as in the case of radium-A, the recoiled atom carries one unit positive electric charge.

As radium-D has a very long period of average life (twenty-four years), there is no time for any α ray emitting substance to be formed, so that the photographic impression is directly due to the recoil atoms. This is further evidence of the similarity between the properties of these recoil atoms and the α rays.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

THE MOUNTAIN WEASEL.—Filippo Cavazza has made an admirably careful study of three hundred and eighty-five specimens of the mountain weasel of the Alps and other European ranges, comparing them (especially as regards the details of the skeleton) with the ordinary weasel (*Putorius nivalis* or *vulgaris*). He concludes that there is a quite distinct sub-species (*Putorius nivalis monticola*), which is restricted to high altitudes, where, however, the typical weasel is commoner. The female is smaller than the typical weasel. The male skull is somewhat less differentiated than in the type; the assumption of a white robe in winter is the rule; and there are other small but distinct differences. Cavazza discusses two hypotheses: (1) Is this mountain weasel a dwarfish race in process of establishing itself, and perhaps arising as a mutation of the typical weasel; or (2) Does it represent a more ancient type, slightly less differentiated than the typical weasel, which was formerly widespread, but is now restricted to its refuge on the high mountains? The discovery of fossil forms may perhaps make a decision possible.

INSECTS AT LIGHTHOUSES.—From a dozen Scottish lighthouses Mr. William Evans, whose lifelong studies on the fauna of Scotland are well known, obtained two hundred and forty-one species of insects (two butterflies, one hundred and fifty-nine moths, eighteen caddis-flies and lacewings, forty diptera, ten beetles, and a dozen more). Both sexes come to the lanterns, but males predominate. To get at the Isle of May, from which the bulk of the records was obtained, many of the species must have flown across several miles of sea. In an interesting introduction to his records Mr. Evans recalls some of the observations that have been made on the wanderings of insects. The "Painted Lady" (*Pyrameis cardui*) has been known to cross the Alps; the "Red Admiral" (*Vanessa atalanta*) landed in numbers on the deck of a vessel bound for Valparaiso when it was five hundred miles from the Lizard; the common "Whites" cross the English Channel in clouds; the famous "Milkweed" butterfly of America (*Danais* or *Anosia archippus*) is said to make the two thousand miles' passage from California to the Sandwich Islands; a death's-head has flown on board a steamer two hundred miles off the Cape Verde Islands. Great flights of dragon-flies have been recorded. Clouds of lady-birds, miles in extent, like smoke from a steamer, have been seen at sea. It is said of a swarm of locusts that passed over the Red Sea in 1889 that it extended for two thousand square miles, and weighed forty-two thousand eight hundred and fifty million tons!

SYNCHRONOUS DEVELOPMENT OF THE SEXES.—It seems that fertilisation of the ova of fishes and echinoderms takes place very soon after spawning. It is stated at hatcheries that the egg of the salmon loses its power of being fertilised in a few minutes. In the case of *Fundulus* the egg loses this power very rapidly. The ripe egg of the starfish dies very quickly unless it is fertilised. It is obviously important, therefore, that the two sets of germ-cells should be shed about the same time, and all the more since the spermatozoa are apt to remain inactive if the eggs of the species are not present. Jacques Loeb, in referring to these matters, cites the case of the sea-urchins at Pacific Grove, where large numbers of *Strongylocentrotus purpuratus* occur on the rocks near shore. Up to a certain date in May, he says, every female opened was full of eggs. On the following day there was spawning on a big scale. This was shown by the enormous foam-formation in little coves, although the sea was only moderately agitated. This foam-formation is due to an increase of organic substances which lower the surface-tension of the sea water, and make the foam more durable. Not a single female opened on that day had eggs, and there was evidence that the sperm is shed simultaneously. The eggs sink much more rapidly to the bottom than do the sperms, and it is probable that the eggs are fertilised before they fall. With a striking specificity the ova activate spermatozoa of their kind, and this acts as a safeguard against hybridisation.

STRANGE HABITATS.—In the little collections of water found in hollows on trees in Epping Forest Mr. D. J. Scourfield has discovered a new copepod (*Moraria arboricola*) which exhibits great tenacity of life. "On one occasion specimens continued in evidence for four and a half years in a three-inch by one-inch glass tube, in which the collection had been brought home. The tube contained nothing in the way of food, except the very innutritious-looking original sediment, and nothing was added during the whole time but a little clean water. Individual specimens, too, have been kept for months in very small tubes, with only the merest trace of sediment, and have remained perfectly active. Such powers of endurance must evidently be of the greatest value to them in their natural surroundings."

In describing his discovery, Mr. Scourfield calls attention to Fritz Müller's study of the fauna living in the natural cups formed by the bases of the leaves of plants belonging to the order Bromeliaceae, to which the pine-apple belongs. Müller described a new ostracod, representing a new genus (*Elpidium bromeliarum*), which occurred almost constantly in association with the bromeliaceous plants in the Brazilian forests, but not elsewhere. Mr. Scourfield found in a similar situation in the Royal Botanic Gardens, Regent's Park, and at Kew the remarkable blind copepod (*Belisarius vigueri*), which had not previously been found in this country. Picado has given a list of two hundred and fifty species of animals from this peculiar kind of environment, and forty-nine were new to science.

THE MASTER CLOCK ON THE LINER AND IN THE CHURCH TOWER.

By G. THOW, M.J.I.

ELECTRICITY has been called in to the aid of clocks for accurate time-keeping, and is indeed valuable. The master clock in the ranges and floors of warehouses, and on board the huge liners, gives time to all the other clocks, and does this in a most interesting way.

On that immense new Cunard liner, the "Aquitania"—the largest British steamer afloat—the Pulsynetic system of electric impulse clocks saves the stewards and the passengers much disputation as to difference in time between the clock in the oak case that ornaments the lounge and the serviceable timepieces here and there in saloons, ladies' cabins, smoking rooms, corridors, officers' quarters, etc. There are a hundred clocks or more on this floating township. Very fine clocks many of them are, copies of old French, Italian, or English masterpieces.

It is a wonderful new invention. Gent, of Leicester, and Edward & Sons, of Glasgow, specialise in this patented system. At Liverpool the largest electric clock in the world, a turret clock, is on this system. The movement of the hands is continuous, and the periodical half-minute impulse of the time-transmitter—the master clock—ensures accurate systematic time-keeping. This clock automatically develops additional power when more power is demanded by wind pressure or snow on the heavy exposed hands. One can therefore set one's watch by the huge turret dials.

A peculiar feature about the pendulum of the master clock is the making the rod of "sinevar," a nickel steel alloy which has a very low coefficient of expansion—that is to say, is not affected by temperature. But, while the land clocks—and there are many in works, warehouses, corporation yards and offices, and church towers—have a pendulum, the circuit of clocks for ships' use is regulated by a balance wheel and hair-spring. The master clock is termed "the transmitter," because its duty is to transmit the half-minute impulse to the circuit of clocks. The pendulum is replaced by a balance wheel and lever escapement, and the gravity lever is replaced by a spring-impelled lever, arranged to drive the escapement through a short train.

With the central marine electric transmitter—the wonderful master clock that controls time for all the clocks on board the gigantic liner—the passengers no longer find the horologes going too fast or too slow; and there is also an automatic device to effect the daily corrections in longitude. By the old method of taking the key and screwing the hands round, the door is opened to forgetfulness and difference of, or rather indifference to, time. With liners such as the "Aquitania," or other mammoth Atlantic hotels, the too numerous clocks would be a burden to the chief steward, and the correct time would be unobtainable. All that is now done in a voyage across the Atlantic to New York is to set the pointer of the master clock to the number of minutes it is desired to retard the clocks, and they are thereby automatically retarded. When sailing eastward the pointer is set to the number of minutes it is desired to advance the time, and the hands go forward to the admiration of the small boy passengers who run from one timepiece to another, including the big one on the staircase.

Marvellous it is to reflect, as one looks at the clock-transmitter, that every half-minute the impulse flies instantaneously to every clock below deck in the engineers' and boiler departments; up above on the chart deck, in the cooks' and stores room; and in the saloons, first, second, and third classes, dining and drawing rooms, libraries, and lounges—to every corner of the magnificent liner. And this is done with never-ceasing regularity—hour after hour, day after day—preventing on board the great steamer, with a population of five thousand people, what is too often seen in towns, numerous public clocks on church towers, halls, and at street corners, all differing in time. In Edinburgh a time-gun is fired from the Castle, and a time-ball drops on a lofty tower on Calton Hill, affording everybody the opportunity of correcting watches and clocks to the exact Greenwich one o'clock time. And, of course, the time-ball at Greenwich is indispensable. This operation the master clock does, not only once every twenty-four hours, but every half-minute—an automatic process. There is no need to turn a key; that is done by the electric impulse. Very clever is the apparatus in use to regulate the electric current. A technical description does not convey much clear information, but one of the features of the Pulsynetic system is the impulsing of the pendulum of the master clock direct by a gravity lever by means of a roller and inclined plane. This ensures the least disturbing effect on the pendulum, and an automatic warning of a weakening battery is given long before the battery is likely to fail. The system is also prevented from stopping on contact, thus preventing the battery from being run down and ruined.

XUM

THE FACE OF THE SKY FOR MARCH.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 2.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Mar. 1	22 48·3	S. 7·6	20 30·6	S. 19·2	21 4·1	S. 17·0	1 14·1	N. 8·1	9 6·7	N. 21·0	6 41·8	N. 22·7	8 9·7	N. 19·8
„ 6	23 7·0	5·7	0 48·5	N. 10·4	21 26·7	16·1	1 35·7	10·5	9 1·8	21·1	6 41·5	22·8	8 9·3	19·8
„ ♍ 11	23 25·4	3·7	5 4·6	N. 26·8	21 52·1	14·6	1 57·5	12·9	8 58·2	21·2	6 41·4	22·8	8 8·9	19·9
„ ♎ 16	23 43·8	S. 1·8	9 18·3	N. 14·8	22 19·5	12·6	2 19·4	15·2	8 56·0	21·1	6 41·5	22·8	8 8·6	19·9
„ ♏ 21	0 2·0	N. 0·2	13 16·9	S. 13·5	22 48·5	10·0	2 41·5	17·3	8 55·1	21·0	6 41·8	22·8	8 8·4	19·9
„ ♐ 26	0 20·2	2·2	18 13·8	S. 26·2	23 18·8	7·0	3 3·7	19·3	8 55·5	20·8	6 42·3	22·8	8 8·2	19·9
„ ♑ 31	0 38·4	N. 4·1	22 52·0	S. 3·8	23 50·5	S. 3·4	3 26·2	N. 21·0	8 57·0	N. 20·5	6 43·0	N. 22·8	8 8·1	N. 19·9

TABLE 3.

Date.	Greenwich Noon. Sun. P	Sun. B	Sun. L	Mars. P	Mars. B	Mars. L	Mars. T	Midnight. Moon. P
	°	°	°	°	°	°	h. m.	°
Mar. 1 ...	−21·7	−7·2	243·4	− 0·6	+14·5	162·1	0 55 *m*	−14·8
„ 6 ...	22·9	7·3	177·5	1·4	14·3	108·8	4 34 *m*	−21·9
„ 11 ...	23·9	7·2	111·6	2·0	14·2	55·0	8 14 *m*	− 4·0
„ 16 ...	24·8	7·1	45·7	2·2	14·3	0·7	11 57 *m*	+17·7
„ 21 ...	25·4	7·0	339·8	2·2	14·6	306·0	3 42 *e*	+20·9
„ 26 ...	25·9	6·8	273·9	2·0	+14·9	250·8	7 28 *e*	− 3·1
„ 31 ...	−26·3	−6·5	207·9					−22·0

P is the position angle of the North end of the body's axis measured eastward from the North point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. T is the time of transit of the zero meridian across the centre of the disc. To find intermediate passages of the zero meridian of Mars apply multiples of $24^h\ 37^m$.

The data for the Moon in the Second Table are given for Greenwich Midnight, *i.e.*, the Midnight at the end of the given day. Those for the planets were given for midnight last year, but are now given for Noon.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

THE SUN is moving Northward at its greatest speed and passes the Equinox $20^d\ 10^h\ 47^m\ e$, when Spring begins. Its semi-diameter diminishes from 16′ 10″ to 16′ 2″. Sunrise changes from $6^h\ 49^m$ to $5^h\ 42^m$; sunset from $5^h\ 37^m$ to $6^h\ 28^m$. There is now considerable solar activity, and a constant watch should be kept on the disc.

MERCURY is a morning star, reaching greatest elongation, 27° West of Sun, on March 1. Semi-diameter decreases from 3½″ to 2½″. Illumination, half disc at beginning of month, nine-tenths at end.

VENUS is an evening star, well placed for observation, being North of the Sun, and approaching Elongation, which is reached on April 24th. At the end of March it does not set till $11^h\ e$. It is then near the Pleiades. Semi-diameter 8″. Illumination two-thirds.

THE MOON.—New $4^d\ 3^h\ 58^m\ m$. First quarter $11^d\ 6^h\ 33^m\ e$. Full $19^d\ 5^h\ 27^m\ e$. Last quarter $26^d\ 4^h\ 22^m\ e$. Apogee $12^d\ 5^h\ e$. Perigee $26^d\ 1^h\ e$. Semi-diameter 14′ 48″, 16′ 10″ respectively. Maximum librations 6^d 5° W., 8^d 7° S., 19^d 5° E., 22^d 7° N. The letters indicate the region of the Moon's limb brought into view by libration. E., W. are with reference to our sky, not as they would appear to an observer on the Moon. (See Table 4.)

MARS is in Cancer, stationary on 22nd. It was in opposition on Feb. 10th. Semi-diameter 6″. Defect of illumination 0″·3 at beginning of March, 0″·8 at end. The North Pole of the planet is now turned towards the Earth and Sun. The Vernal Equinox of the planet's northern hemisphere took place on October 19th, and the planet is in the part of its orbit that corresponds with the end of May on Earth. The present opposition is unfavourable as regards distance, but favourable as regards altitude.

JUPITER is too near to the Sun for convenient observation, being in conjunction on April 1. No satellite phenomena are given this month.

SATURN is an evening star in Gemini, stationary on 11th. Angle P − 6°·8, B − 25°·7. Polar semi-diameter 8¾″, Major axis of ring 43″, minor 18½″. Eastern elongations of Tethys (every fourth given) $1^d\ 6^h{\cdot}0\ e$, $9^d\ 7^h{\cdot}2\ m$, $16^d\ 8^h{\cdot}5\ e$, $24^d\ 9^h{\cdot}7\ m$, $31^d\ 11^h{\cdot}0\ e$; of Dione (every third given) $1^d\ 1^h{\cdot}9\ m$, $9^d\ 7^h{\cdot}0\ m$, 17^d noon, $25^d\ 5^h{\cdot}1\ e$; of Rhea (every second given) $7^d\ 1^h{\cdot}9\ e$, $16^d\ 2^h{\cdot}7\ e$, $25^d\ 3^h{\cdot}5\ e$. For Titan and Japetus E., W. stand for Eastern and Western elongations; S., I. for Superior and Inferior Conjunctions. Titan $1^d\ 3^h{\cdot}8\ e$ W., $9^d\ 10^h{\cdot}0\ e$ E., $17^d\ 2^h{\cdot}5\ e$ W., $25^d\ 8^h{\cdot}9\ e$ E. Japetus $15^d\ 6^h{\cdot}3\ e$ I.

URANUS is invisible, a morning star, but badly placed. It was in conjunction with the Sun on February 5th.

NEPTUNE was in opposition on Jan. 22nd in Cancer. Semi-diameter 1″, magnitude 7·7.

TABLE 4. Occultations of Stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance.		Reäppearance.	
			Time.	Angle from N. to E.	Time.	Angle from N. to E.
1916.			h. m.	°	h. m.	°
Mar. 9 ...	16 Tauri	5·4	10 15 *e*	68	11 12 *e*	241
,, 9 ...	17 Tauri	3·8	10 17 *e*	112	11 11 *e*	201
,, 9 ...	20 Tauri	4·1	10 46 *e*	55	11 35 *e*	260
,, 9 ...	q Tauri	4·3	10 48 *e*	10	11 4 *e*	300
,, 9 ...	WZC 224	6·8	11 24 *e*	119	—	—
,, 9 ...	BD+23°·540	7·0	11 25 *e*	80	—	—
,, 9 ...	η Tauri	3·0	11 30 *e*	123	0 13 *m**	192
,, 10 ...	28 Tauri	5·2	0 11 *m*	122	—	—
,, 10 ...	27 Tauri	3·7	0 23 *m*	157	0 40 *m*	161
,, 12 ...	125 Tauri	5·1	2 20 *m*	158	2 44 *m*	183
,, 13 ...	48 Geminorum	5·8	7 43 *e*	50	8 31 *e*	326
,, 14 ...	58 Geminorum	6·0	2 2 *m*	115	2 58 *m*	242
,, 15 ...	Neptune	7·7	2 16 *m*	145	3 6 *m*	223
,, 20 ...	370 B Virginis	6·0	10 6 *e*	122	11 15 *e*	303
,, 21 ...	BD−11°·3398	6·7	—	—	1 5 *m*	314
,, 24 ...	b Scorpii	4·7	2 42 *m*	80	3 50 *m*	312

From New to Full, disappearances take place at the Dark Limb; from Full to New, reäppearances.
The asterisk indicates the day following that given in the date column.

Attention is called to the occultation of the Pleiades on March 9–10.

GREENWICH TIMES OF MERIDIAN TRANSIT OF CERTAIN BRIGHT STARS.—These are given to facilitate the determination of time by observations with small transit instruments. The times for intermediate days may be obtained by simple interpolation. The Greenwich time of the stars crossing the meridians of other places may be obtained by expressing the longitude of these places in time, diminishing them by 9ˢ·83 per hour, and proportionately for fractions of an hour, then applying the result to the tabular time—positively for West longitudes, negatively for East ones.

Observers who know Greenwich Time can use the Table to obtain their South Point.

SUN after clock Mar. 2, 738ˢ·82, Mar. 7, 672ˢ·21, Mar. 12, 595ˢ·46, Mar. 17, 510ˢ·95, Mar. 22, 421ˢ·41, Mar. 27, 329ˢ·81, April 1, 238ˢ·83. These are the equations of time for the moment of solar transit at Greenwich.

TABLE 5.

Day.	Sirius.	α Cancri.	Regulus.
	S. Dec. 16° 36′.	N. Dec. 12° 11′.	N. Dec. 12° 22′.
	h. m. s.	h. m. s.	h. m. s.
Feb. 29.....	8 8 15·28 *e*	10 20 21·50 *e*	11 30 10·47 *e*
Mar. 10.....	7 28 56·05 *e*	9 41 2·36 *e*	10 50 51·36 *e*
,, 20.....	6 49 36·78 *e*	9 1 43·18 *e*	10 11 32·25 *e*
,, 30.....	6 10 17·55 *e*	8 22 24·03 *e*	9 32 13·14 *e*

VARIABLE STARS.—Stars reaching their maxima in or near March, 1916, are included. The lists in recent months may also be consulted. (See Table 6.)

TABLE 6. LONG-PERIOD VARIABLE STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m. s.	° ′		d.	
T Cassiopeiae	0 18 37	+55 19	6·7 to 12·5	443	1916—Mar. 12
R Arietis	2 11 17	+24 40	7·3 to 13·2	187	,, Apr. 6
R Ceti	2 21 42	− 0 34	7·0 to 13·0	167	,, Feb. 6
T Camelopardi	4 31 48	+65 59	7·0 to 13·5	370	,, Apr. 18
X Camelopardi	4 34 29	+74 58	7·3 to 13·1	142	,, Apr. 5
Geminorum	6 9 45	+22 32	3·3 to 4·2	232	,, Mar. 13 (min.)
R Lyncis	6 54 18	+55 27	6·5 to 14·0	379	,, Apl 20
S Ursae Majoris... ...	12 40 15	+61 33	7·0 to 12·5	226	,, Mar. 8
V Ursae Minoris ...	13 37 10	+74 45	7·5 to 8·7	71	,, Feb. 26
R Canum Venaticum ...	13 45 18	+39 58	7·4 to 12·2	328	,, Feb. 15

Mira Ceti has passed its Maximum, but is still observable in the early evening. See "KNOWLEDGE" for December.
Minima of Algol $2^d\ 7^h\cdot6\ e$, $5^d\ 4^h\cdot4\ e$, $17^d\ 3^h\cdot6\ m$, $20^d\ 0^h\cdot4\ m$, $22^d\ 9^h\cdot2\ e$, $25^d\ 6^h\cdot0\ e$. Period $2^d\ 20^h\ 48^m\cdot9$.
Principal Minima of β Lyrae $10^d\ 6^h\cdot2\ e$, $23^d\ 4^h\cdot3\ e$. Period $12^d\ 21^h\ 47^m\cdot5$.

XUM

COMETS.—The following ephemeris of Taylor's Comet (*e* 1915) is calculated for Greenwich Midnight from the elements given in "Notes on Astronomy" on page 39:—

Day.	Right Ascension.	North Declination.	Log Distance from Sun.	Log Distance from Earth.
Feb. 17 ...	$5^h\ 42^m\ 26^s$	26° 19′ ...	0·1856	9·9012
„ 25 ...	5 58 16	28 27 ...	0·1891	9·9326
Mar. 4 ...	6 16 0	30 8 ...	0·1936	9·9652
„ 12 ...	6 35 24	31 22 ...	0·1990	9·9975
„ 20 ...	6 56 12	32 11 ...	0·2053	0·0293
„ 28 ...	7 17 42	32 36 ...	0·2123	0·0609

On March 28th the Comet is about 2½° West of Castor.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
Mar. 1–4 ...	166°	+ 4° N.	Slow, bright.
„ 1–14 ...	175	+ 10 N.	Slow.
„ 18 ...	316	+ 76 N.	Slow, bright.
„ 24 ...	161	+ 58 N.	Swift.
„ 27 ...	229	+ 32 N.	Swift, small.
Mar. to May ...	263	+ 62 N.	Rather swift.

REVIEWS.

GEOLOGY.

The Earth: Its Life and Death.—By A. BERGET. Translated by E. W. BARLOW. 371 pages. 30 illustrations. 8-in. × 6-in.

(New York: G. P. Putnam's Sons. Price 7/6 net.)

This is an astronomer's translation of a book on the physics of the Earth written by a French oceanographer; and one naturally finds that, while the physics and astronomy are well done, the geology is of a distinctly archaic flavour. In the preface the author states an evolutionary thesis of the Earth. Every organism is born, lives, and dies; and he asks whether the Earth itself also follows this general law, and lives in a way analogous to that in which terrestrial life does. The analogy is followed closely throughout the book, and determines its plan. The opening chapter on the birth of the Earth is all Laplace and the nebular theory. The author has apparently never heard of the modern meteoritic and planetisimal theories. The translator, however, has added some modernising notes. The second chapter, on the age of the Earth, contains some very musty geology. We are told, for example, that the strata of the primary era are classified by geologists into Silurian, Devonian, Carboniferous, and Permian. The author also holds the exploded view that atmospheric temperatures were very high in the primary era, and have progressively decreased to the present time. Joly's moderate estimate of the age of the Earth is rejected as based on uncertain assumptions, and an age of between one thousand million and two thousand million years is advocated on the authority of radio-active and sedimentation methods, which, however, involve even more uncertain assumptions than Joly's.

Succeeding chapters treat of the form, magnitude, and movements of the Earth; the force of gravity; terrestrial magnetism and radio-activity; the rhythmic movements of the ocean, and of marine and atmospheric circulation. The penultimate chapter, on the attack and defence of the continents, is a study of denudation and deposition; and the final chapter, entitled the old age and death of the Earth, gives the usual picture of refrigeration and stagnation of life, with possible rebirth by collision with another dark planet. The illustrations are scanty, and not particularly well reproduced. The book may be found useful in bringing together in one view the large aspects of Earth problems.

G. W. T.

The Birth-time of the World, and other Scientific Essays.—By J. JOLY, M.A., Sc.D., F.R.S. 307 pages. 28 illustrations. 9-in. × 6-in.

(T. Fisher Unwin. Price 10/6 net.)

A physicist whose bent is towards geology has a wide range, and these essays illustrate this fact, as well as the versatility of their author. They range from such mighty subjects as the birth of the world and a pre-material universe to the physics of skating and the origin of pleochroïc haloes. Five of the twelve essays are geological, or have a geological application; and Professor Joly is especially concerned with radio-activity in relation to geology. Other essays deal with the abundancy and urgency of life, the bright colours of Alpine flowers, the use of radium in medicine, the latent image, and the question of the existence of other minds than ours. The last-named examines the evidence for intelligent life on Mars, especially with regard to the origin of the so-called canals. Professor Joly advances the novel explanation that the "canals" are the tracks raised on the surface of the planet by the near approach of an infalling satellite. The essay which provides the title of the book defends the estimates of geological time made by Professor Joly, based on the exact measurement of the effects of denudation and the sodium salts of the sea, and criticises the assumptions upon which the much greater estimates by radio-active methods are based. Apparently Professor Joly believes that the lowermost horizon of metamorphic and igneous rocks represents the consolidated crust before sedimentation began; but this is opposed to the views of most specialists in Archaean geology.

These essays make fascinating reading, and each and all bear the impress of an original mind. The book is illustrated by many excellent photographic plates.

G. W. T.

NOTICES.

THE MURCHISON FUND.—We are most pleased to chronicle that the Geological Society has this year awarded the Murchison Fund to Mr. G. W. Tyrrell, our Geological Editor.

SLATE RHEOSTATS.—We have received from Messrs. Isenthal & Company their catalogue of rheostats of the type in which the resistance wire is wound on slate bars or slabs, the edges of which have been grooved, so that the wire forms a continuous narrow-pitched spiral.

FORTHCOMING BOOKS.—In Mr. Murray's Quarterly List we notice an announcement of a work by Viscountess Wolseley, entitled "In a College Garden," which will deal with the daily life at the Women's Horticultural College at Glynde, founded by the author. To the series of Imperial Institute Handbooks, which is edited by Professor Wyndham Dunstan, a volume will be added on "Vegetable Fibres met with in Commerce and Industry," by Dr. Ernest Goulding. A new edition on "The Study of Animal Life," by Professor J. Arthur Thomson, is promised, and a book on "Form and Functions," by E. F. Russell.

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